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The Materials Outlook

WASHINGTON, D. C.--The Federal Government is driving hard to force a greatly enlarged capacity to produce the basic metals for American industry. Threats, coaxing and promises of tax relief are having their effect. The aim is to have--within two or three years--sufficient capacity for normal civilian use and still plenty of metals for keeping ourselves and Europe fully armed. Here are the prospects for several of the leading materials:

Aluminum--Negotiations are nearing completion with five major producers of the light metal to provide capacity which will make possible an increase of 80% over pre-Korean output.

Cobalt--Announcement is expected soon of a contract with a producer of cobalt to increase production of this important alloying element by 1 million lb per year for the next five years.

Tungsten--Another big contract for the expanded production of this metal is expected momentarily. However, it will take many months before any increase in production is achieved.

Many other plans are supposedly in the hopper of the Defense Minerals Administration. No information is being released on these plans yet, but it is safe to assume that copper and manganese are high on the list for relief if any is possible.

Some orderliness seems to be emerging from the confusion which has befuddled Washington ever since the police action started in Korea. Now, for the first time, the military requirements for a given period are clearly stated. General Harriman, Defense Production Administrator, is reported ready to challenge any list of military requirements if he has cause to suspect that the demands are out of line.

As reported here previously, the Controlled Materials Plan is set to go into effect for the third quarter. Preliminary forms have already been printed and are now being given trial runs in the Capitol. One important question remains to be answered before the plan finally takes over. That is: Shall the CMP apply only to defense production, or shall it cover all production? Current official feeling is that the plan should cover all industry. Steel, copper and aluminum will be the only materials affected when the plan first goes into action.

(Continued on page 4)

The Materials Outlook *(continued)*

The latest application of newly found technical knowledge is in the manufacture of the new Curtiss-Wright airplane propeller. A hot extrusion process is employed which results in a better propeller blade being made in less time and for less cost than former high production methods. Steel used for the extrusion is aircraft quality chromium-nickel-molybdenum alloy. In addition to other advantages, the new method saves steel. A 400-lb billet is used to produce a 10-ft, 200-lb blade. Formerly, a blade of similar size produced by machining and welding required 750 lb of steel on which to start.

Many reports of black market operations in steel and aluminum are circulating. The majority of black market steel comes from Belgium or Japan, and its price is rising fast. Prices are expected to reach $300 per ton soon. The pattern seems to be something like this: Speculators either import the foreign steel or buy up the supplies as they are imported and then hold them for ransom prices. Thus far regular steel channels have been given a clean bill of health.

Because of the severe shortage of most alloying elements, the two new boron steels developed cooperatively by several groups working through the American Iron & Steel Institute are expected to be used as replacements for the NE and Alternate steels. Details as to the properties and uses of the new steels are expected soon when experimental heats poured by several steel companies can be tested.

Nickel shortages are readily explained by looking at current production as opposed to the peak output of the last war. To begin with, there is a 6,000,000 lb per year reduction caused by marginal producers withdrawing from operation. In addition, nickel is being stockpiled at the rate of 6,000,000 lb per year. At current production there remains about 14,000,000 lb for all current needs. Cuban and additional Canadian sources are being encouraged to produce again primarily for stockpile purposes; in fact, government contracts have been signed for nickel coming from these sources.

It doesn't make much difference now, but future automobiles might make different use of materials than do present-day cars. Le Sabre, GM's experimental car,uses cast aluminum alloy for the head and cylinder block, rather than cast iron; cylinder walls are lined with a heat resistant cast iron; combustion chambers in the head are machined instead of cast.The head uses stainless steel valve seat inserts and the flywheel is made of high tensile bronze. Valve guides are also bronze; intake valves nickel-chromium alloy steel; and exhaust valves are sodium cooled. Pistons are aluminum alloy.

Materials & Methods
MARCH 1951

Heat Resistant Ceramic Coatings Permit Substitutes for Critical Materials

by DWIGHT G. BENNETT, Dept. of Ceramic Engineering, University of Illinois

Recently developed ceramic coatings make possible the high temperature use of noncritical iron and low carbon steel, and provide additional protection for heat resistant alloys.

• FOR A LONG TIME men have been concerned with protecting metals from corrosion. This is because metallic elements, with few exceptions, are happiest in such forms as oxides and salts and will revert to them at every opportunity. Of most concern are the metals and alloys which, by their strength, workability and availability are of economic and strategic importance.

In this article, primary attention is directed toward the protection from corrosion (principally oxidation) of iron and steel and their alloys at operating temperatures higher than organic coatings can withstand. Such temperatures might reasonably be considered to begin at about 500 F.

Prior to World War II, iron and many steels were protected from lower temperatures by organic finishes applied by painting and lacquering or "Japanning." For resistance to higher temperatures, such alloying elements as chromium and nickel were used in substantial amounts.

With the advent of critical alloy metal supply problems of World War II and ever increasing demands for the efficiencies obtainable at higher operating temperatures, determined and sustained efforts were made to utilize inorganic or ceramic coatings for high temperature metal protection. A significant portion of this work was initiated at the University of Illinois in 1943 with the Power Plant Laboratory of the Air Materiel Command acting in the role of sponsor. Other universities, research organizations and government agencies cooperated, each one usually having some particular phase as its special problem.

In general, the purpose of ceramic coatings is either to permit the use of metals at operating temperatures higher than normally possible or to greatly prolong their useful life at conventional operating temperatures. More specifically, ceramic coatings can be employed to: (1) protect high temperature alloys against corrosion by the atmosphere encountered in service; (2) serve as heat barriers, thus permitting the use of higher gas temperatures at the same metal temperatures; (3) smooth out temperature gradients in metals, reducing the occurrence of hot spots; (4) protect low alloy metals, making it possible to use them in place of critical materials; and (5) resist contaminants (chemical and bacteriological) and facilitate decontamination. Metals which stand to profit from ceramic coating can be roughly classified into three groups as follows: (a) ingot iron, Ti-Namel iron and low carbon steel, (b) ferrous alloys, and (c) nonferrous metals and alloys.

In conventional porcelain enameling, a ground coat is used as a base for a cover coat. In the application of the high temperature resistant ceramic coatings considered in this paper, a base coat is used to protect the metal from the corrosive effects of oxygen or, in some cases, from the products of combustion, such as those produced during operation of an aircraft engine. In addition, a top coat consisting of a combination of refractory crystalline materials like diaspore, alumina Opax, Uverite and Ceria held together by a minimum amount of a low-radiant-energy transfer bonding glass can be applied. Such a coating is not dense and glassy, its relatively open structure allowing the passage of oxygen, but absorbing and reflecting some of the radiant energy which falls upon it.

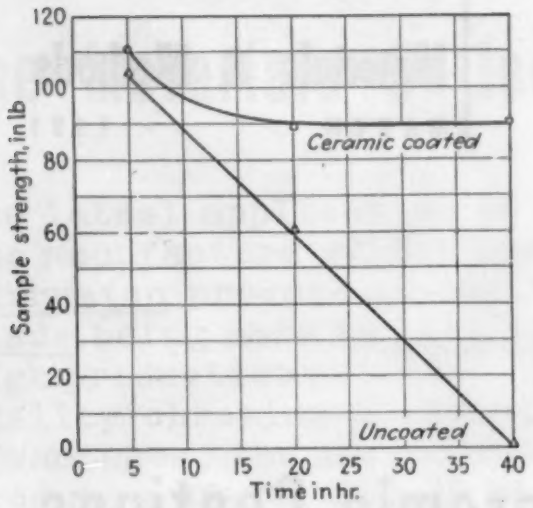


Fig 1—A sample of ceramic coated 18:8 stainless steel type 347 proved to be far more heat resistant than its uncoated counterpart when both were exposed to prolonged heating at 2000 F.

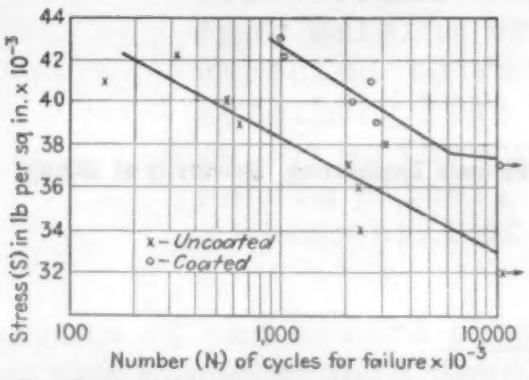


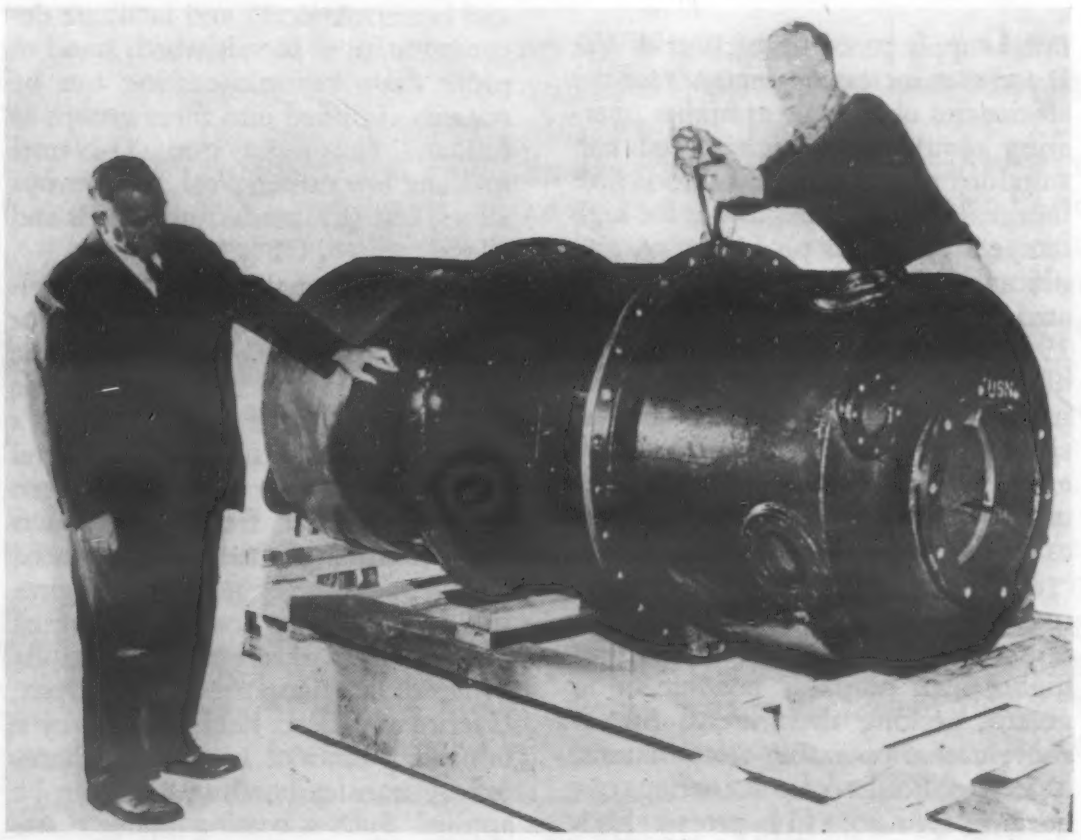
Fig 2—Both the fatigue life and fatigue strength of a type 347 stainless steel sample were increased when a ceramic coating was applied. Tests from which these data were drawn were conducted at a temperature of 1800 F.

Coating Applications

The uses of ceramic coatings to protect metals from high temperatures are so numerous and important that they fairly stagger the imagination. Farm yards and city junk yards bear mute evidence to the corrosive effect of oxygen on iron and steel at normal temperatures. When industrial processes involve the use of such metals at temperatures of from 500 to 2000 F, excessive losses from oxide corrosion occur, not in years, but in weeks, days or even hours of operating time. A few specific examples include space heaters, smoke pipes, superheated steam pipes, heat exchangers, heavy metal on roasting and siliconizing tube furnaces, and annealing covers used in heat treating metal. As a general statement, it can be said that the use of high temperature ceramic coatings should be considered in all installations where heat is accelerating the corrosion of any metal.

With increasing emphasis on national defense and the growing shortage of important alloying elements necessary for high temperature applications, interest has been stimulated in the use of heat resistant ceramic coatings. There is now much experimental evidence to indicate that the proper application of these ceramic coatings will often permit the high temperature use of relatively noncritical iron and low carbon steel. Even in the case of many alloy metals there is quite convincing evidence that properly applied ceramic coatings will (1) increase their fatigue strength and fatigue life, (2) prolong their usefulness at specified operating temperatures, or (3) permit their use at even higher temperatures for considerable periods of time.

Some of the high temperature parts for which ceramic coating is being considered in the national defense program include exhaust stacks or collector rings, tail pipes, tail cones, flame tubes, turbine buckets and insulating foil blankets.



The ceramic coating on this submarine exhaust muffler withstands the extreme thermal shock resulting when heated to exhaust temperatures and submerged in cold sea water. (Courtesy Porcelain Enamel Institute)

Ceramic Coating Requirements

In any well considered program of high temperature coating research and development, due consideration must be given to the kind of protection desired, the types and properties of the metals to be coated, and the types and properties of ceramic materials available in coating formulation.

Low carbon steel, for example, must be protected from rapid and progressive surface oxidation. Steels of high alloy content are not subject to rapid surface oxidation but, under certain conditions, may develop grain boundary oxidation, or so-called intergranular corrosion. Although some alloys are quite resistant to chemical attack, irons and alloy steels should, in general, be protected from acidic corrosion.

By taking such factors into consideration, the formulation of the proper high temperature ceramic coatings can be developed along sound lines. The coating for iron or low carbon steel, for example, must fuse and seal off oxygen early in the heating cycle, before excessive oxidation can take place. In the case of alloy steels, the fusion of the base coat must be delayed until sufficient metal oxide is formed to produce good adherence. These two extremes will serve to illustrate that a ceramic coating which just matches the oxidation rate of one particular alloy may not be suitable for another alloy with a different rate of oxidation.

A further requirement is that the coating properly match the thermal expansion of the base metal. Finally, a ceramic coating which fits the metal and adheres well to it must display long resistance to high temperature heating. This resistance involves two important properties: (a) the rate of solvent action of the coating upon the base metal, and (b) heat stability of the coating itself. While some coat-

ings volatilize only slightly, others have been found to give up as much as 38% of their alkali content during prolonged heating. Since the alkali oxides are notable for high thermal expansion, their volatilization will result in the enamel coat chipping or spalling after long exposure to heat.

In evaluating these ceramic coatings for specific high temperature applications, button fusion tests, coefficient of thermal expansion determinations and cyclic long heat tests are routine. Some of the more promising coatings are given tensile and fatigue tests. Finally, service tests on engine test stands or in actual operational units are carried out.

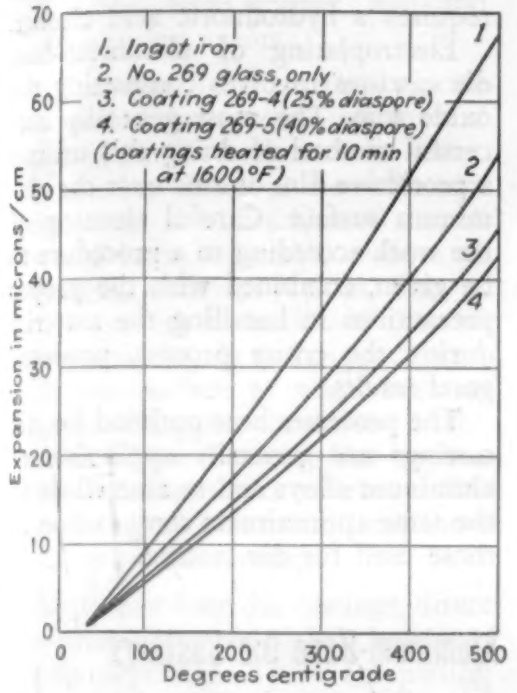
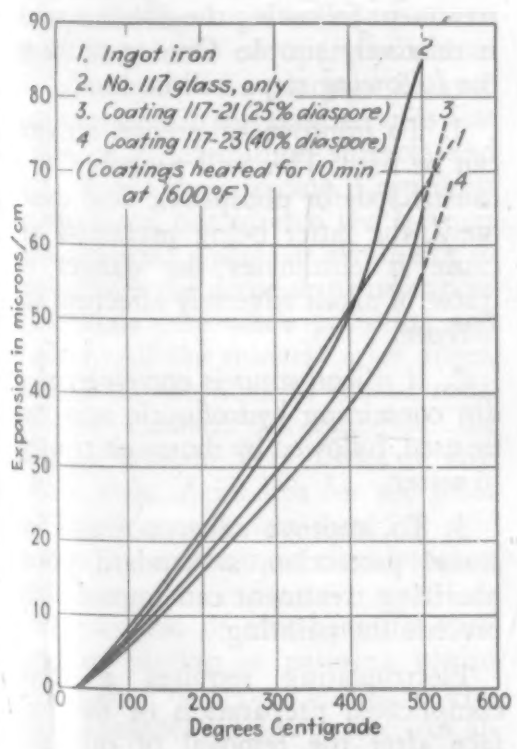


Fig 3—Bonding glass used in ceramic coatings must have thermal expansion characteristics similar to those of the metal to be coated. The glass in 3a (above), therefore, is unsatisfactory for use in coatings for ingot iron, its expansion rate being considerably slower than that of the iron. Enough similarity exists between the curves in 3b (below), however, to justify the use of No. 117 glass in a ceramic coating for the ingot iron.



Test Results

Some of the advantages derived from the use of ceramic coatings are indicated by the test results recorded in the graphs which accompany this article. Fig 1 shows the effect of extended heating on the tensile strength of two 18:8 stainless steel type 347 samples, one of which is ceramic coated. There is a decided difference in the tensile strengths of the two bars, which becomes more pronounced as heating is prolonged. In this test, as well as in tests of SAE 1020 steel, ceramic coated samples proved to be considerably more resistant to heat than uncoated ones.

Some rather significant data on the increase in fatigue strength and fatigue life imparted by a ceramic coating are shown in Fig 2. The simple application of a ceramic coating to type 347 stainless steel increased its fatigue strength and fatigue life greatly. As heating at 1800 F was continued for 10 and 20 hr, the coated specimens maintained their superiority—but to a diminishing degree.

When insulative and radiation reflective crystalline top coatings are used, it is important that they remain affixed to the base coat without any spalling off and that they do not melt down to a glassy and ineffective state. The selection of bonding glass to be used is extremely important because its function is to bond together particles of the refractory materials, assist in bonding the coating as a whole to the base coat, and impart the desired expansion to the coating containing it. Fig 3a shows the thermal expansion curves of a particular bonding glass and those for two top coatings containing the glass, together with 25 and 40% of mill-added diaspore, respectively. Alongside these is a curve for the thermal expansion of ingot iron. It can be seen that even the bonding glass alone does not have a high enough expansion rate to keep up with the expansion of the iron. In Fig 3b, on the other hand, it is shown how two such diaspore type top coats containing a much higher expansion bonding glass would fit the iron's thermal expansion rate quite satisfactorily.

The usefulness of a ceramic top coating in one particular application is shown in Fig 4. When an Inconel

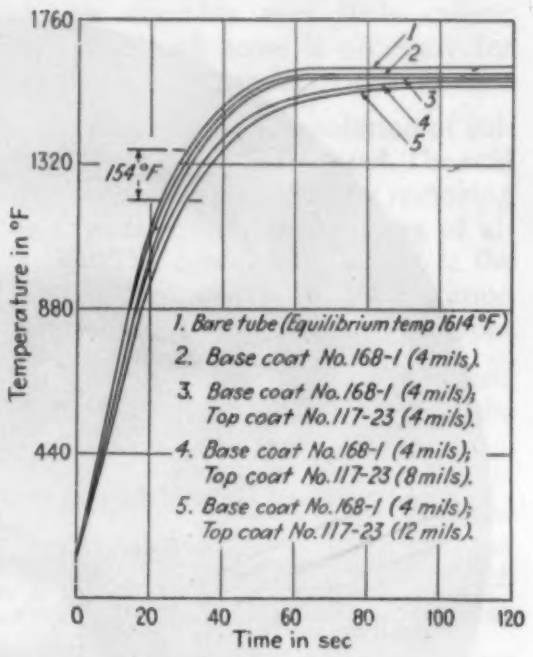


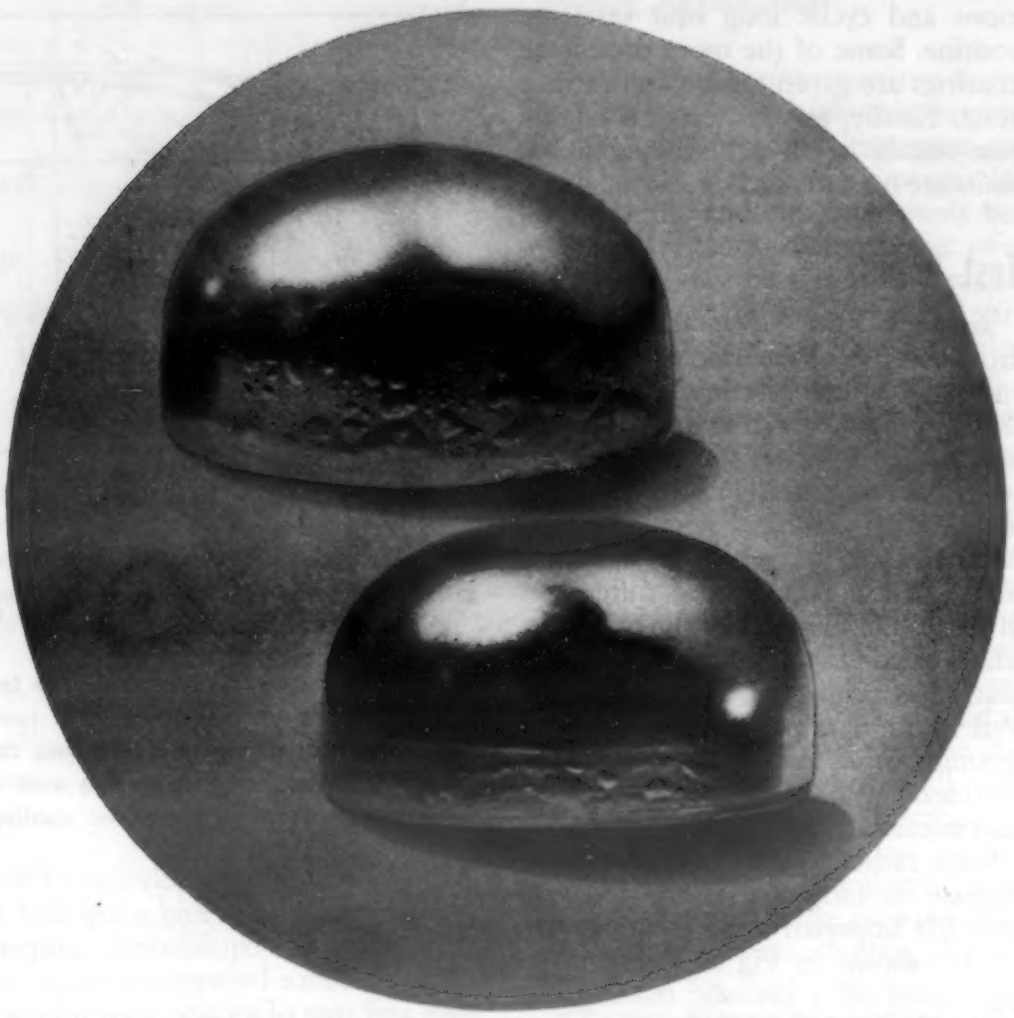
Fig 4—These curves demonstrate the temperature difference between the outer surface of an ordinary Inconel flame tube and the surfaces of others which were internally protected with ceramic coatings.

flame tube was internally coated with a ceramic-base coat and a top coat 12 mils thick, the equilibrium temperature difference between its outer surface and that of an uncoated tube was about 75 F when heating was carried on in a 1600 F temperature range. On the other hand, the temperature lag or transient state temperature difference at 30 sec was 154 F. So great a difference can be of definite importance in cases where such things as projectiles are operating at temperatures near the melting point of the metal in their motive parts.

All of the background information which has been accumulated about high temperature ceramic coatings during the past several years has indicated that there are many useful fields for their application which are as yet untouched.

In any undertaking which involves high temperatures, the severity of operating conditions, the reasonable length of metal life under such conditions, the cost and availability of metals, and the value of the end product must all be evaluated when ceramic coatings are being considered. It appears to be reasonably certain, however, that with the decreasing backlog of iron ore and alloying elements and the relative abundance of ceramic materials, high temperature resistant ceramic coatings will play an increasingly important part in both war and peacetime economies.

This article is based on a paper presented at the annual meeting of the Porcelain Enamel Institute on Oct. 31 and Nov. 1 and 2, 1950.



Proper surface conditioning of die castings minimizes tendency of such blistering as shown here. (Courtesy National Die Casting Co.)

Preparing Zinc-Base and Aluminum-Base Die Castings for Finishing

Cleaning and surface conditioning of die cast parts is frequently required before finishing to improve corrosion resistance or appearance.

by **D. F. SEYMOUR**, Factory Superintendent, The Diversey Corp.

● ZINC AND ALUMINUM ALLOYS are the principal materials formed by die casting. This high-production method of machine casting permits low-cost forming to close tolerance. The surface obtained will be satisfactory for some items, but there are many pieces made by die casting, for which additional surface treatment is desirable, or necessary, to improve either corrosion resistance or appearance. The surface finish imparted is usually a painted, enameled or electroplated one, and the material requires special preparation before the actual finishing operation to obtain best results.

Each of the alloy groups presents its own problems in the preparation of the surface for electroplating or other finish. With zinc-base alloys we are bothered by the reactivity of zinc with the various alkalies and acids necessary for the surface preparation and by the variation in porosity which results in a thin, comparatively dense skin and a very porous core.

With aluminum alloys the most annoying problems are the smut that develops on the surface of the casting and the very thin oxide film that forms almost instantly on aluminum surfaces upon exposure to air. Aluminum-base die castings contain a percentage of silicon as an alloying element. Silicon is responsible for the formation of the smut during cleaning, and removal of the silicon smut requires a hydrofluoric acid cleaner.

Electroplating of aluminum-base die castings involves combatting the oxide film. The most generally successful method of doing this utilizes a protective film of zinc over the aluminum surface. Careful cleaning of the work according to a procedure to be given, combined with the proper precautions in handling the material during the entire process, produces good results.

The processes here outlined for die castings are generally applicable to aluminum alloys and to zinc alloys of the same approximate composition as those used for die casting.

Aluminum-Base Die Castings

Surface preparation of aluminum-base die castings should start with an alkaline cleaning to remove oil, grease and shop dirt. This could be:

1. Soak tank cleaning, or
2. Spray cleaning.

If a protective coating is not to be applied, the alkaline cleaning can be followed by rinsing and drying, and the castings are ready for use.

If the pieces are to be painted, the treatment following the alkaline wash is relatively simple. One or more of the following steps will be used:

1. To improve adherence, an etch can be used. This will probably be a caustic soda or phosphoric acid treatment, the latter being preferred because it eliminates the danger of traces of alkali adversely affecting adherence.

2. If silicon smut is encountered, a dip containing hydrofluoric acid can be used, followed by thorough rinsing in water.

3. To improve adherence and increase protection, a standard phosphatizing treatment can immediately precede the painting.

Electroplating requires a more complicated preparation of the surface after the removal of oils and

greases. The steps for the most common system of preparation and plating are as follows:

1. Pickle in a mixture of nitric and hydrofluoric acids. This operation removes the alloying elements from the surface of the casting. It may be necessary to repeat this step to guarantee complete removal.

2. Rinse thoroughly. Although the oxide film again forms after the pickling and rinsing operations, the surface is free from copper, lead and silicon alloying agents.

3. Immerse in a sodium zincate solution consisting of a mixture of zinc oxide and caustic soda in water. This solution dissolves the oxide film and replaces it with a film of zinc. A ½- to 2-min immersion suffices to produce a sufficiently thick film of zinc to prevent formation of the aluminum oxide again and to produce an oxide-free surface to which electrodeposits of copper, chromium, silver, etc. will adhere. The zinc film imparts surface characteristics to the aluminum casting which are similar to those of zinc-base die castings.

As on zinc-base die castings, direct chromium or copper-nickel-chromium can be deposited. There are plating processes for direct deposition of chromium onto aluminum, in which case the surface is freed of copper, lead and silicon as before, and then plated. Deposition of the zinc film as a preliminary to plating is usually the simpler and surer method, however.

Zinc-Base Die Castings

Zinc-base die castings are painted and plated by more nearly conventional sequences of operations than are aluminum die castings because zinc surfaces do not oxidize at as fast a rate as do aluminum surfaces and smut is not troublesome. Care must be exercised not to etch the castings with too strong acids or alkalies or to cut through the dense skin and expose the porous core when polishing and buffing. All the mineral acids attack zinc, as do solutions of caustic soda. Alkaline cleaners for zinc-base die castings contain very little, if any, caustic soda. Acid dips for use prior to plating contain less than 5% acid by volume, and in most cases less than 2%.

Preparation of zinc-base die castings for plating or painting begins with a soak or spray cleaning operation to remove oil and grease. An alkaline cleaning compound is generally used here.

If the work is to be painted, paint can be applied directly after cleaning. Better adherence will be obtained if the work is treated in one of the following manners after cleaning, and prior to painting:

1. Acid etching with any acid will improve the adherence of the organic films. The microscopic etch makes possible a keying of the film to the metal surface. The acid also neutralizes any traces of alkali that may not have been rinsed from the surface.

2. Phosphatizing not only makes possible a mechanical keying of the film to the microscopically rough and porous surface but inhibits corrosion should penetration of the paint film occur. The phosphate film prevents corrosion from progressing from the point of penetration back under the remainder of the film.

The sequence of operations normally employed for preparing zinc-base die castings for electroplating includes the removal of bulk soil by alkaline immersion or spray cleaning followed by:

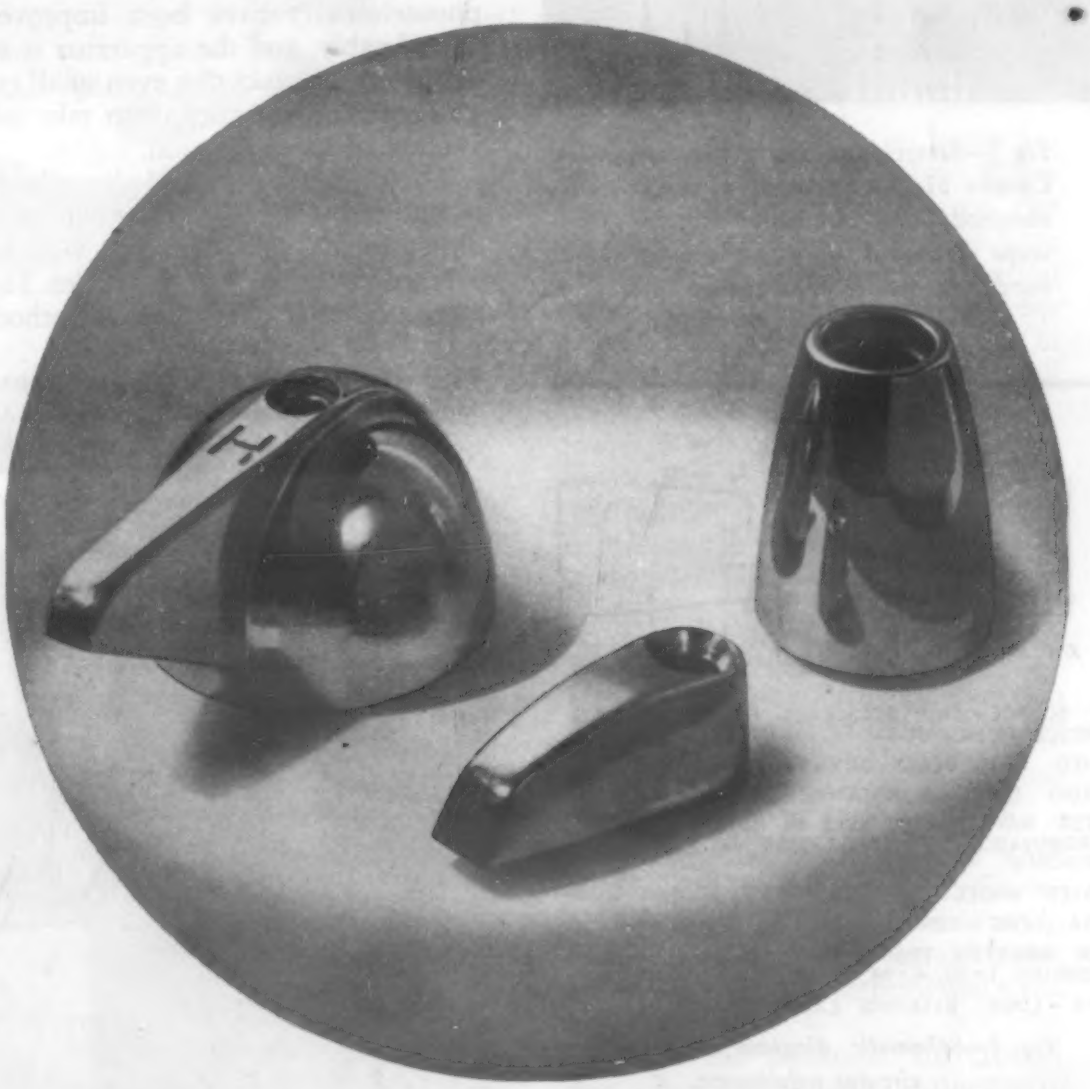
1. Electrocleaning. The electrocleaner contains very little caustic soda, although some is necessary for good electrical conductivity.

2. Acid dipping. A solution of sulfuric acid, 2% or less, is used. The acid dip activates the surface by removing any oxide, carbonate or traces of alkalies. The concentration used is the one which just causes gas evolution in the immersion interval available.

3. Electroplate. Unlike brass and steel, zinc-base die castings cannot be directly plated with conventional bright nickel solutions. A copper deposit must be made prior to nickel plating to prevent the formation of immersion deposits of nickel, which result in streaked and blistered nickel.

As both zinc and aluminum alloys have good resistance to atmospheric corrosion, the plating of die castings is most frequently done to improve appearance, or to match the color or luster of some other part of an assembly. For this reason nickel and chromium plating is the deposit most used. Study of the plating process itself is not here intended, but the surface treatments outlined have been found especially successful as a preliminary to chromium plating.

These zinc die castings were properly cleaned before plating, resulting in high luster finish.



Photoelastic Stress Analysis Useful in Design of Metal Parts

Part 1 — Two-Dimensional Method

Knowledge of the stresses and their distribution in parts under actual service loading often enables better and more economical designs.

by **M. M. LEVEN**, Westinghouse Research Laboratory, Westinghouse Electric Corp.

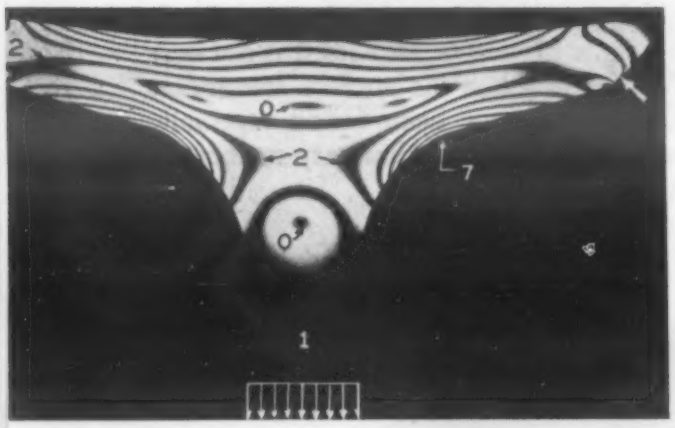
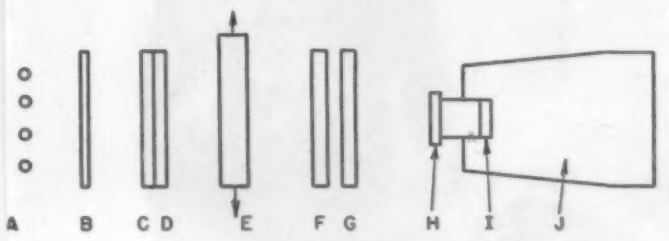


Fig 1—Stress pattern of a two-dimensional Catalin 61-893 model of a poppet valve, obtained using a circular crossed polariscope giving a dark background. Black bands denote integral fringe orders as shown by numerals.



A – LIGHT SOURCE – TWO STAGGERED ROWS OF GREEN FLUORESCENT LAMPS.
B – FLASHED OPAL GLASS DIFFUSION SCREEN.
G – POLAROID DISKS IN ROTATABLE MOUNT.
F – QUARTER WAVE PLATE DISKS IN ROTATABLE MOUNT AND REMOVABLE FOR CONVERSION TO PLANE POLARISCOPE.
E – STRESSED MODEL.
H – CAMERA LENS – LONG FOCAL LENGTH.
I – FILTER WRATTEN 77A OR CORNING 1-60, 4-96, AND 3-68 COMBINED.
J – CAMERA – LONG BELLOWS EXTENSION.

Fig 2—Schematic diagram of a diffusion circular polariscope.

● THE PHOTOELASTIC METHOD of stress analysis can serve as a useful guide in the design of many metal parts and structures. By determining the stresses and their distribution prevailing in a design under actual service loading, it often enables a better and more economical design. In recent years the techniques and procedures of photoelasticity have been improved considerably, and the apparatus is so simple to construct that even small engineering organizations can take advantage of its application.

There are two principal photoelastic techniques. The older of the two, two-dimensional photoelasticity, will be covered in this first of two articles. The more recently developed method, three-dimensional photoelasticity, will be covered in the second article.

In the two-dimensional photoelastic method of stress analysis, models are cut from flat sheets of certain materials. When these models are loaded in a manner similar to the prototype and examined in polarized light, optical retardation or interference effects are observed which can be related to the state of stress. When using monochromatic polarized light, a configuration of light and dark bands, known as fringes, will appear in the model, as shown in Fig 1. This configuration of fringes is referred to as a fringe or stress pattern, and is generally unique for every shape of model and type of loading.

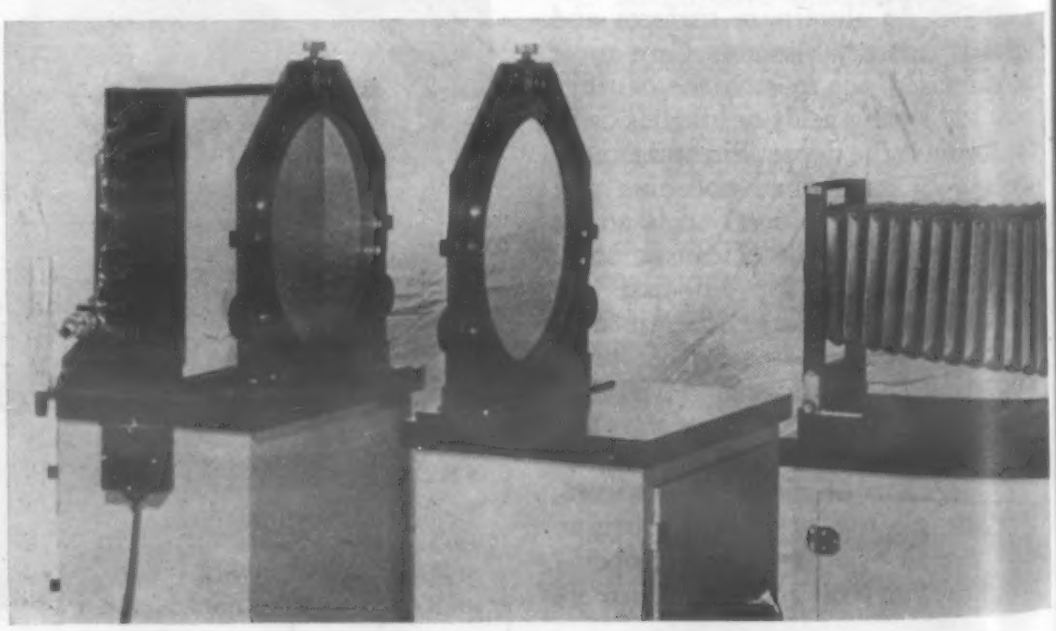
By the simple process of counting fringes and multiplying by a calibration constant, known as the fringe value, the stresses can be obtained throughout the model. Thus, in Fig 1 the maximum fringe order at the valve fillet is 7.0, the fringe value (obtained from a separate calibration test) is 580 psi, and the maximum stress at the fillet is, therefore:

$$S = 7.0 \times 580 = 4060 \text{ psi}$$

The Polariscope

The instrument used for producing the polarized light and obtaining the stress pattern is known as a polariscope. With the discovery of polaroid, a synthetic polarizing material, the polariscope has been greatly simplified and its cost materially reduced. Fig 2 shows, schematically, the parts of a large field diffusion polariscope which is inexpensive, simple and effective. The illumination from such a polariscope is very intense and no align-

Fig 3—A 16-in. dia diffusion polariscope. Left cabinet holds fluorescent-lamp light source and polarizer. Center cabinet carries analyzer. Straining frame with model is placed between these two cabinets. Right cabinet holds the camera equipment.



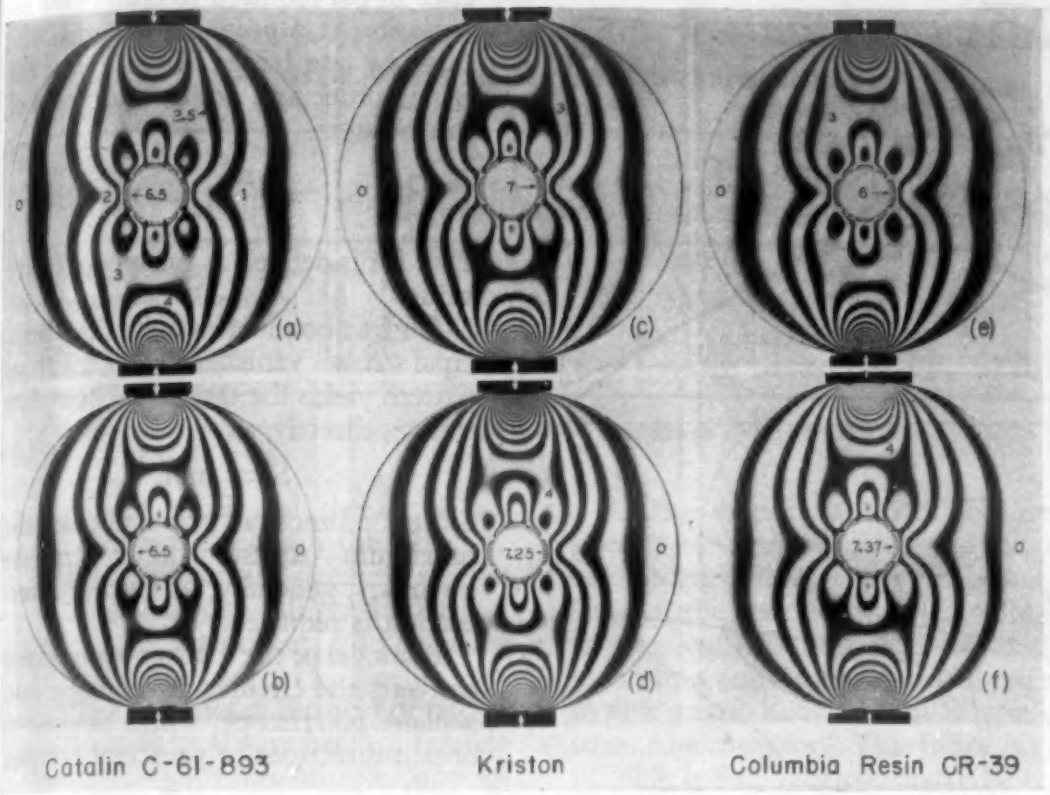
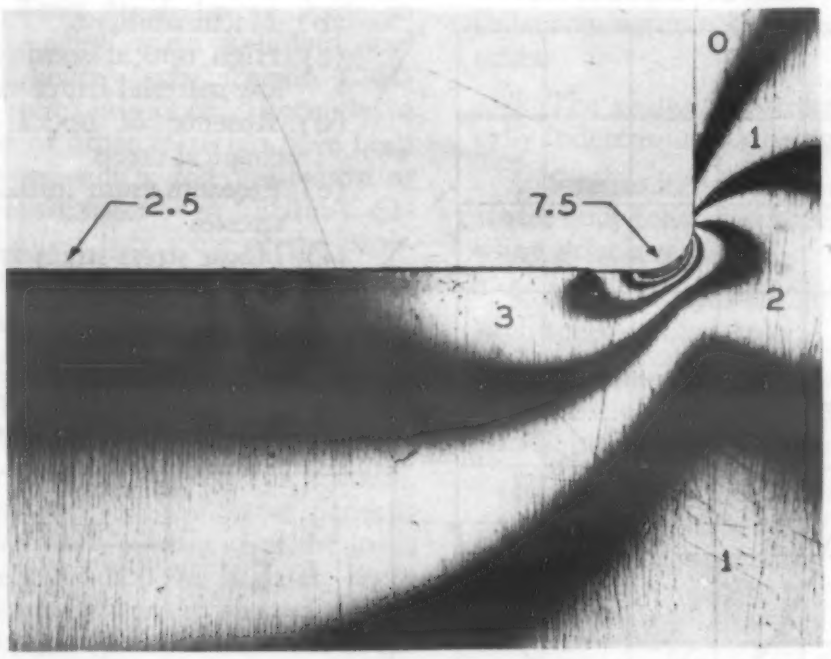


Fig 4—Stress patterns of Catalin, Kriston and CR-39 disks with central circular holes subjected to diametral compression. Loads and dimensions are the same for all three disks.



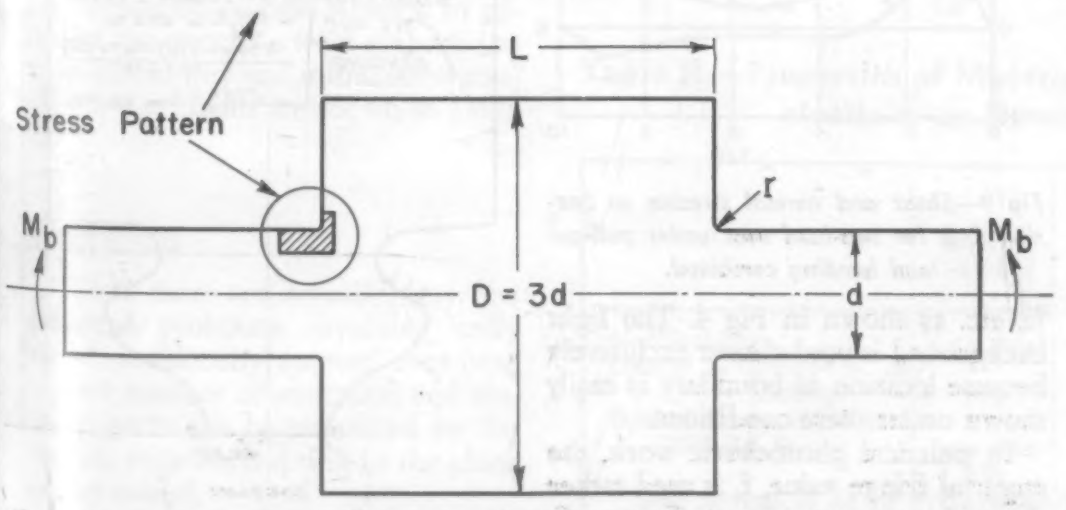


Fig 5—Stress pattern of portion of bar in bending with central enlarged section. Material: Amber Bakelite.

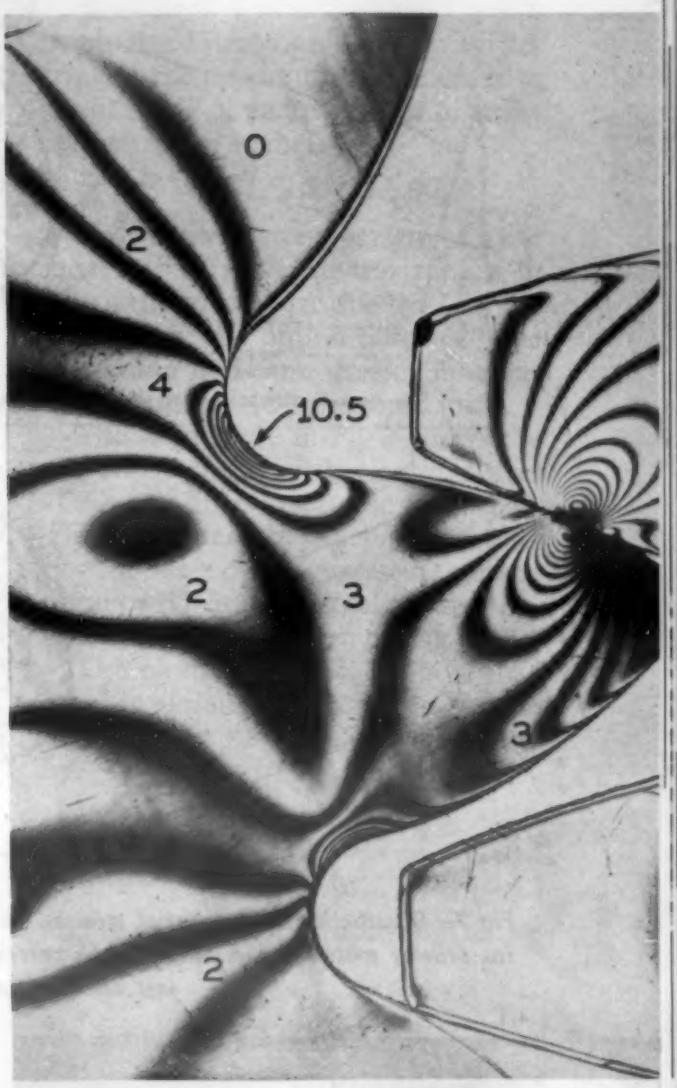


Fig 6—Stress pattern of railway motor pinion model under applied torque of 224.6 lb-in. One pinion tooth is carrying the entire load, with the second tooth just coming into contact.

ment is necessary since no lenses are used other than the camera lens. When using a diffusion polariscope the models need not be polished or have plane parallel faces. Merely coating the model with an oil of suitable index of refraction will suffice. Halowax Oil #1000 or #1007 works well on all photoelastic materials.

Fig 3 shows the diffusion polariscope used at the Westinghouse Research Laboratories in which the polaroids are 16 in. in dia and are mounted on portable wooden cabinets.

The Stress Optic Law

In the circular polariscope shown in Fig 2, the retardation induced at any point in the stressed model is

$$R = Ct\ (S_1 - S_2), \text{ where}$$

R denotes the retardation in wave lengths, C is the stress-optic coefficient of the material and has the inverse dimensions of stress, t is the thickness, and $(S_1 - S_2)$ is the principal stress difference.

When the polaroids are crossed (*i.e.* a dark background) extinction of

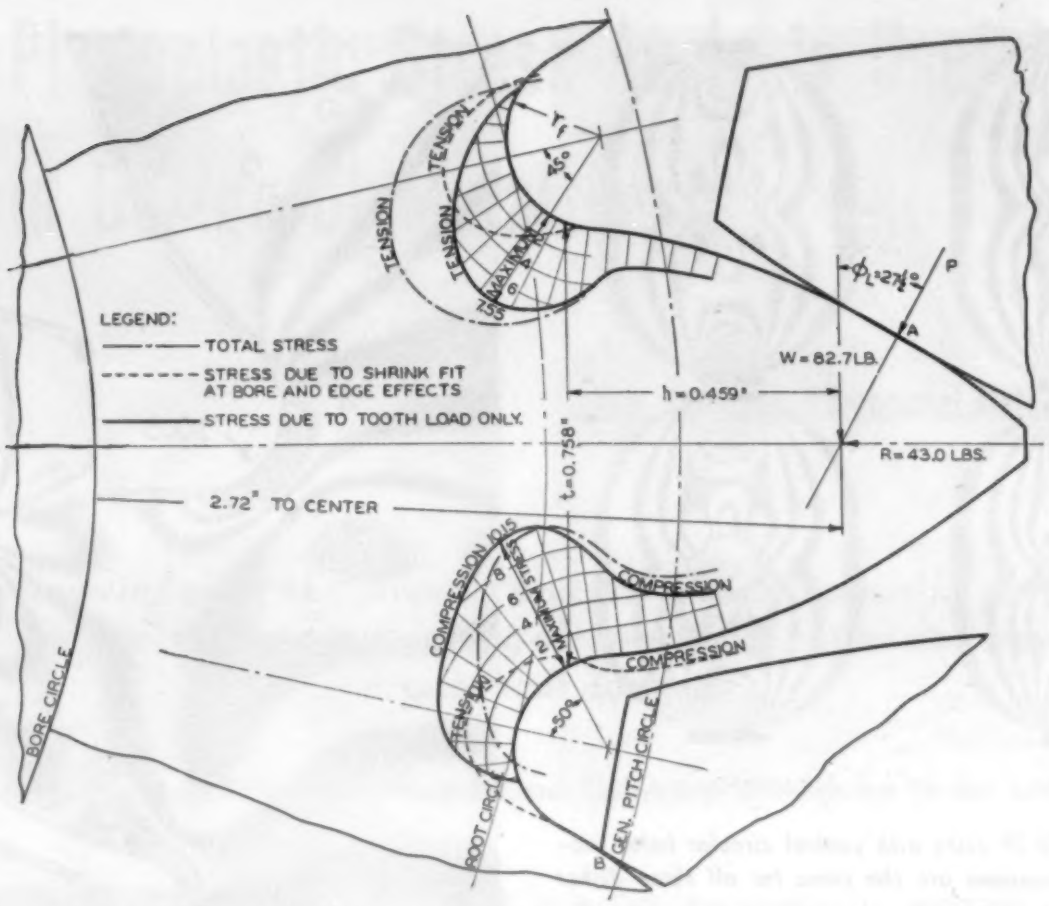


Fig 7—Distribution of tangential stresses (in fringes) at root fillets due to tooth load alone, for railway motor pinion. Single tooth carrying the entire load (point A) with second tooth just coming into contact (point B).

Fig 8—Stress pattern of two-land turbine blade root model subjected to a pull-out load and a bending load, as in Fig 10.

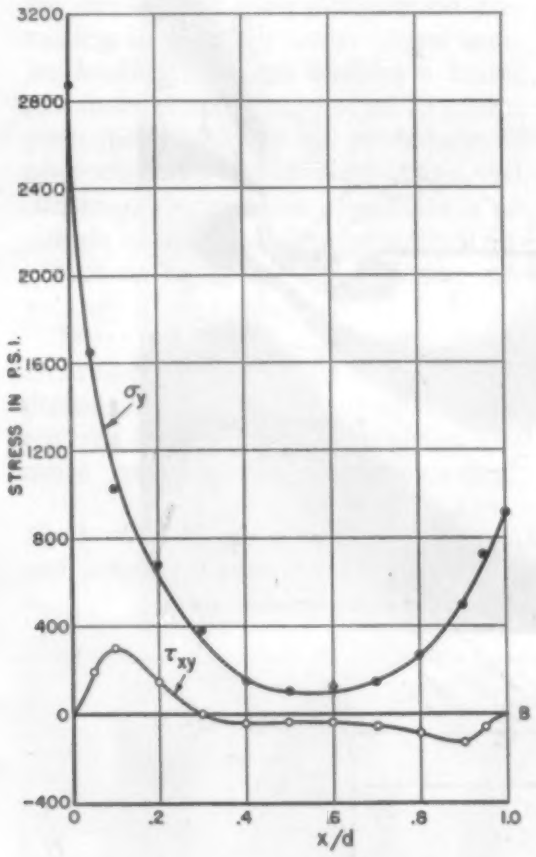


Fig 9—Shear and normal stresses on Section O-B for two-land root under pull-out and bending combined.

the light on the camera screen occurs when the retardation is an integral number of wave lengths (see Fig 1). When the polaroids are parallel (light background), extinction occurs when the retardation is an odd number of half wave lengths, that is, the black fringes denote fringe orders of ½, 3/2, 5/2, etc. as shown in Fig 4. The light background is used almost exclusively because location of boundary is easily shown under these conditions.

In practical photoelastic work, the material fringe value, f, is used rather than the stress-optic coefficient C, where f is defined as the stress difference in psi required to change the retardation at a point in a model 1-in. thick by one fringe. Then if n is the fringe order at a point in a model of thickness, t:

$$S_1 - S_2 = \frac{nf}{t} = nF, \text{ where}$$

$F = f/t$ is defined as the model fringe value.

On free boundaries one of the principal stresses vanishes so that the stress pattern yields the tangential boundary stresses directly, as

$$S = nF.$$

Since for almost all practical cases, the maximum stresses occur on the boundary, generally, no further information is required.

Removal of the quarter-wave plates converts the circular polariscope into a plane polariscope, which is used to obtain directions of principal stresses.

Materials

An ideal photoelastic material must have, among others, the following properties:

(a) Transparency
(b) Machinability
(c) High optical sensitivity (*i.e.* low material fringe value)
(d) Absence of optical or mechanical creep
(e) Freedom from initial or time stresses
(f) Linear stress-strain and stress-fringe relations
(g) High modulus of elasticity so that the model deformations

Fig 10—Shear and normal forces on Section O-B of turbine blade root.

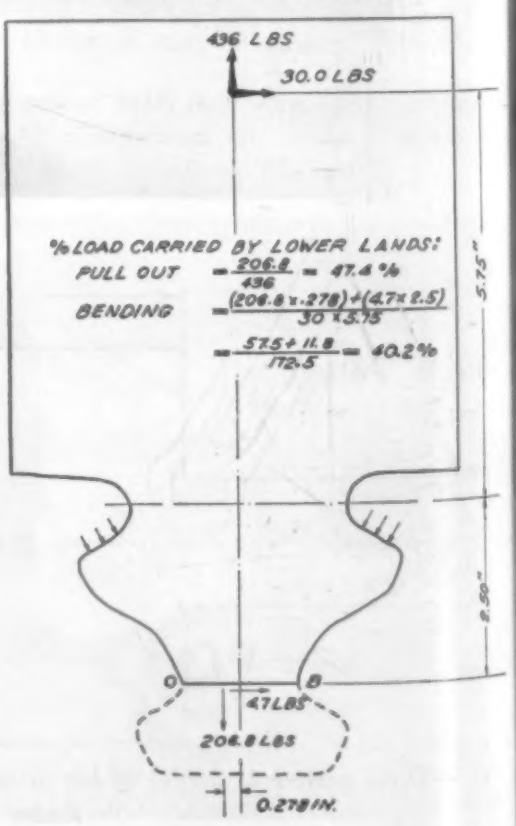


Table I—Properties of Materials Used for Two-Dimensional Photoelastic Tests at Room Temperature

	Catalin C-61-893	Kriston	Columbia Resin CR-39	Celluloid *	Annealed Marblette
Material Fringe Value, Psi	86	80	100	230	75
Modulus of Elasticity, Psi	630,000	540,000	315,000	300,000	530,000
Ult TS, Short Time Test, Psi	15,000	8,200	7,000	7,000	4,500
Optical Proportional Limit, Psi	7,000	4,000	3,500	4,500	3,500

* *Properties are representative since a wide variation exists for different grades of Celluloid.*

are small and the shape remains essentially the same

(h) High tensile strength so that the model will not fracture at the regions of load application

Advancements in the field of photoelasticity have always been intimately connected with the introduciton of better model materials. The first material used was glass. It satisfies a great many of the essential requirements of a photoelastic material. The main objections to glass are the difficulty of machining and its low optical sensitivity. Great strides were made in photoelasticity when celluloid and then Bakelite (now Catalin C-61-893) were introduced. Recently, a number of other materials have been introduced which, for one reason or another, are inferior to Catalin C-61-893. Table I lists some of the properties of importance, photoelastically, generally given for five materials commonly used for two-dimensional tests.

Disks with central holes, of the same dimensions, were cut from these five materials and subjected to the same diametral loads, for Catalin, Kriston and CR-39. Stress patterns were obtained 10 min after the loads were applied and 48 hr later. From such stress patterns it was possible to compare the optical sensitivities of the materials as well as the optical creep and formation of time stresses. In addition, the materials were evaluated as to machinability and initial stress condition. The results are shown in Table II.

Applications

While there are, actually, very few practical problems involving truly two-dimensionally stressed members, a great number of structural and machine parts can be simulated by flat models with loads acting in the plane of the model.

Two-dimensional photoelasticity has been used for a great variety of stress analysis problems including:

1. The determination of localized stresses for regular geometric shapes or discontinuities. The maximum stress at the discontinuity (fillet, hole, groove, etc.) is determined and divided by a convenient nominal stress, to give a ratio known as the "factor of stress concentration". This factor is applicable in full to brittle materials and in full or part to materials subject to fatigue.

2. The determination of stresses in specific machine parts, such as spur gears, turbine blade roots, railway car wheels, rails, curved links, rollers, miscellaneous automobile parts, and many others.

3. The analysis of stresses in statically indeterminate structures.

4. Stresses in dams and earthworks where body forces can be simulated by using gelatin models.

5. Study of transient stresses using high-speed photography.

6. The study of fluid flow using the photoelastic effect developed in certain liquids by the viscous shear.

Fig 5 shows the stress pattern of a portion of a bar in bending containing a central enlarged section. The nominal stress

$$S = \frac{Mc}{I} = \frac{6\,M_b}{t\,d^2}$$

is obtained photographically as 2.5 fringes; the maximum fringe order at the fillet is 7.5; and the factor of stress concentration is, therefore

$$k = 7.5/2.5 = 3.00.$$

Fig 6 shows a stress pattern of a flat model of a railway motor pinion in which the stresses are due to: (1) the shrink fit at the pinion bore; (2) the machining and time stresses inherent in Catalin; and (3) the tooth load.

The solid curve in Fig 7 shows the tangential stress distribution in fringes at the root fillets due to the tooth load. This is obtained by algebraic subtraction of the no-load stresses (pattern not shown) from the total stressses obtained from the pattern of Fig 6.

The photoelastic results show that, for this pinion, the maximum tension in the upper fillet may be calculated by:

$$\text{maximum } S_c = 1.90\left[\frac{6\,W\,h}{f\,t^2} - \frac{R}{f\,t}\right]$$

and the maximum compression at the lower fillet by:

$$\text{maximum } S_c = 1.90\left[\frac{6\,W\,h}{f\,t^2} + \frac{R}{f\,t}\right]$$

where W is the tangential component and the R the radial component of the tooth load, h and t are dimensions shown in Fig 7, and f is the face width of the pinion.

Fig 8 shows the stress pattern of a flat model of a two-land turbine blade root subjected to a pull-out and a bending load. Fig 9 shows the shear and normal stresses across section O-B which can be calculated using the stress pattern of Fig 8, and additional principal stress-direction data obtained from the plane polariscope. From Fig 9 the total normal and shear forces on O-B can be obtained and, consequently, the percentage of the loads carried by the lower lands can be calculated as shown in Fig 10.

Table II—Properties of Materials Used for Two-Dimensional Photoelasticity as Determined From Disk Tests

	Catalin C-61-893	Kriston	Columbia Resin CR-39	Celluloid	Annealed Marblette
Machinability	Very good	Poor	Poor	Fair	Good
Optical Sensitivity (% of Catalin)	100	108	92	42	123
Optical Creep in 48 Hr (3000 Psi Stress)	Less than 1%	3.5%	23%	18%	22%
* Time Stresses in 48 Hr	Very small	Very small	Very small	Very small	Very small
Initial Stresses in Models	Very small	Very small	Very small	Very small	Very small

* *Models were kept coated with Halowax Oil #1000.*

New Insulating Materials and Coatings Extend Electric Motor Life

by **RICHARD L. CUSTIS**, Reliance Electric and Engineering Co.

Fiberglas tubing and laminates and new insulating varnish effectively withstand corrosive atmospheres, high temperatures, and effects of dirt and oil.

● RECENT DEVELOPMENTS in electric motor design and construction have been directed principally toward enabling motor users to secure appreciably longer life of motors, with less maintenance and less time out for major repairs and overhauls. Advances in motor insulation materials, in particular, can be cited as major contributors to these improvements. Specifically, insulation materials and coatings have been designed to combat more effectively those operating conditions which affect motor service life most severely—corrosive atmospheres, total winding temperatures, dust and dirt, oil, and vibration.

Among such newer developments are more effective materials and improved coating methods, especially for insulation of motors (Class B) designed for high temperature service. Out of Reliance's study of varnished tubing, for example, grew a testing program, covering various types of available tubing suitable for coil leads in both semi-enclosed and open-slot design motors. Directly from this, in turn, stemmed a new tubing known as BH 649 Fiberglas tubing, developed by Bentley, Harris Manufacturing Co., Conshohocken, Pa.

It was found that varnish-impregnated tubings, although high in initial dielectric strength, subsequently failed because of varnish film separation when held in a bent position over long periods of time. With a plastic coated B-H sleeving this difficulty was overcome and more effective insulation secured by the disposition of the inside cushion of fibers to accept a subsequent coat of impregnating varnish.

Initially, the film of this tubing showed a tendency to flow under severe conditions of pressure and heat. This problem was satisfactorily solved through further research and test work, which culminated in the development of BH 649 Fiberglas Tubing. This is now used in place of canvas-reinforced phenolic material in all Reliance standard precision-built motors.

Another new material which also contributes to increased insulating efficiency and appreciably longer motor life is Glastic. This is a Fiberglas reinforced polyester laminate developed by Laminated Plastics, Inc., of Cleveland. This material is now being used in selected motor components, including such items as middle sticks, slot wedges, armature end laminations, collars, and coil washers.

Replacing cloth-based or canvas-reinforced phenolic laminates and asbestos-filled materials commonly used for these purposes, this low-pressure, fast-curing plastic laminate has, by comparison, already clearly demonstrated its superior qualities. Among them are: high heat resistance, arc resistance, impact strength, flexural strength and low water absorption. These characteristics are especially important to efficient operation of motors under the high humidity conditions encountered in some industrial applications.

Glastic is currently being extended to use in the molding of solid shapes, such as brush studs, end shelves and coil supports. For these parts, a special formulation is used. Compounded from selected polyester resins and Fiberglas, it is different from the standard Glastic sheet material used for the various components previously mentioned in that it can be successfully compression-molded into intricate shapes of variable cross section.

Applications such as the foregoing aptly exemplify the increasingly important role that new and improved materials are coming to play in the insulation of motors installed for operation under such adverse conditions as the high ambient temperatures of a steel mill, the corrosive fumes of a chemical processing plant, or the high humidity of a paper mill.

Other important applications of new insulating materials are to be found in the use of glass-mica-glass for slot liners and in phase-to-phase insulation of motor coils, in the glass-sleeved head connections of modern motor construction, and in the adoption of Fiberglas tape to tie down stub connections to coil heads.

Plant experience shows that in addition to contributing to greater operating efficiency and longer life of electric motors, these newer, improved insulating materials provide a number of worthwhile advantages conducive to good maintenance practice and economy. Glastic slot sticks and BH 649 Fiberglas Tubing or sleeving on leads resist breakage from vibration to a far greater extent than other materials previously used, thereby reducing equipment shutdowns and limiting necessary maintenance expense to a minimum on this score.

New Insulation Coating

Exposure of motors to extreme moisture, acids, alkalies, oil, dirt and abrasive dust likewise places a premium on the protective values provided by the materials used for insulation. A special insulation treatment, known as Reli-X, adopted by Reliance as standard production procedure is representative of the progress being made in this direction.

Varnish-coating of motor windings has a four-fold purpose: (1) to penetrate windings; (2) to drive out air and fill in voids; (3) to build up a hard, tough protective film on exterior surfaces of windings; and (4) to bond the wires firmly to each other and to the metal parts with which these wires come in contact. Accomplishment of these broad objectives provides a number of definite benefits. It increases dielectric strength of windings against grounds, and against shorts to other parts of the windings themselves. It increases resistance of coils to moisture, and it improves the heat transfer coefficient of the windings. Bonding of wires to each other and to the framework of armatures, rotor or stator helps hold the coils of which they are part against movement caused by expansion and contraction due to heat, by magnetic forces in the motor, or (in the case of rotating parts) by centrifugal forces.

The "ideal" varnish treatment would do all this, but in practice it is not actually possible. However, of present-day coating techniques applied in standard motor-insulation practice, it is believed that the Reli-X treatment comes the closest to approaching the results desired.

In this process, wound rotors, stators or armatures are first preheated to drive out all moisture, then immediately dipped in a new synthetic polymerizing varnish of viscosity and specific gravity which will give thorough penetration. All voids are filled with this thermo-setting plastic impregnating material, resulting in a solid mass of wire and insulation.

Next, windings are baked under controlled temperature to drive out all volatile content, then immediately immersed in the same synthetic polymerizing varnish to give maximum fill and build-up. A second, thorough baking follows to produce a tough, hard, glossy protective covering. Spray application of an oil-resisting, air-drying, orange-colored enamel provides the final protective finish coat.

Uniformity of results in the Reli-X varnish treatment is secured chiefly through close control of four operating variables: (1) viscosity, (2) specific gravity of the varnish used, (3) oven temperature, and (4) processing time.

It has been found that vibration due to misalignment or other causes is less likely to damage windings which are more firmly bonded together, as provided by this improved insulation treatment. Grounds, short circuits and wire breakage are reduced.

Impregnation of wound rotors, stators or armatures with the new synthetic polymerizing varnish also produces a smooth, hard surface highly resistant to acids, alkalies and other corrosive fumes. Additional dipping operations assure improved varnish build-up and body. Windings can be cleaned easily as no crevices exist for collecting concentrations of dust and dirt.

Spraying of windings with a special orange-colored, air-drying, oil-resisting enamel as the final protective finish coating is proving particularly helpful to motor users in expediting periodic maintenance inspection, cleaning and routine servicing. Against the orange color, dirt and other foreign material show up plainly. Since the material dries to a hard, smooth finish, removal of accumulated oil and deposits can be easily accomplished before dust and dirt have the opportunity to combine with atmospheric moisture to form gummy sludge on windings, and in the ventilating passage of motors.

To summarize, motors today called upon to meet high temperature service conditions require insulation with a much greater margin of safety than was available even a relatively few short years ago. Performance reports from factory and mill managements and maintenance departments indicate that new insulating materials and coatings of the types outlined give motors the highest degree of protection yet realized against foreign materials, excessive temperature rise and similar operating abuses.

This added protection means that motors can now be treated to remain on the job longer, with less maintenance and fewer "times out" for repairs.

New insulating materials and techniques have resulted in lowered cost of maintenance and less down time.

Localized Flame Hardening of Steel Cutters Reduces Warpage

Satisfactory hardness obtained and rejects reduced by selective treatment of laminated steel.

by A. P. ALEXANDER,

Works Metallurgist,

International Harvester Co.

Hardening of binder blade is accomplished in this fixture. Water in trough under the jets limits heat-affected zone.

• WHEN SERVICE REQUIREMENTS demand the hardening of a part of a steel piece while holding the remainder of the steel in a relatively soft condition, the materials engineer can obtain the differential hardness by (1) choosing or producing a differential hardenability in the steel, or (2) heat treating the steel by a process that will develop full hardness in only part of it. The first case usually involves a differential carbon content in the hardening and nonhardening areas of the steel, and this can be obtained by using a laminate of high- and low-carbon steels, by carburizing, nitriding, carbonitriding, etc. In the second case only the areas to be hardened are heated, and this localized heating is accomplished by flame hardening, induction hardening, etc. Selection of material and process depends upon several considerations, such as the value of the part, the permissible degree of warpage, and the depth to which hardness must be developed.

At the Memphis Works of International Harvester Co. the choice of material and process for a baler knife brought these factors into consideration. The knife, a piece of steel about 12 in. long, 3/8 in. thick, and tapering from 4½ to 3½ in. in width, cuts only twine in normal service, but it is required to shear a ½-in. bar of steel as a preliminary test, so that if a pair of pliers should fall into the path of the cutter while in service the knife will not be broken. This means that the knife must have high hardness at the cutting edge, with softer, shock-resisting steel behind it.

The fact that the knife must be capable of repeated resharpening determined that a laminated steel must be used here. A laminate of low-carbon steel with a high-carbon plain steel containing 0.90% carbon was the material chosen. The formed pieces were heated to 1650 F in a furnace and quenched in water to develop the proper hardness in the high-carbon layer, which formed the cutting edge of the knife. The pieces were beveled along the cutting edge so that the hardened layer projected beyond the soft low-carbon steel.

The difference in carbon content, and, therefore, in volume change upon quenching caused the knives to warp rather badly in heat treatment, however. A straightening operation was required after hardening and tempering. The proportion of rejects from the operation was high enough to warrant studying it with a view to producing a more satisfactory method of hardening the steel.

The procedure finally developed involves the heating of the laminated steel by a flame to produce localized hardening along the edge, and far enough behind it to permit resharpening without the need for a rehardening of the steel. To insure that the heat will be concentrated in the region near the edge during hardening, the remainder of the knife is immersed in water during the time the flame plays upon it. It was found too, that sufficient hardness was developed by quenching in oil, and that this less drastic quench helped to reduce warpage.

For heat treatment the shaped piece of laminated steel, which has been given a preliminary bevel grind, is placed in a special hardening fixture. This consists of a shallow trough in which the dull side of the knife rests in water, leaving the beveled edge projecting above the water and in line with a row of gas jets. The piece remains in the fixture for 45 to 50 sec, in which time the exposed steel reaches a bright red heat, indicating the austenitizing temperature. A timer then sounds a bell, and the knife is seized with a pair of tongs by the operator, lifted from the fixture, and immediately dropped into an oil bath to quench the steel.

A draw at 400 F follows, and the knife is then given a final sharpening on a grinder. Hardness in the finished piece is Rockwell C 58 to 61.

Warpage has been so reduced that the straightening operation required after the former hardening procedure has been eliminated. The percentage of rejects also has fallen. Hardness obtained with the oil quench is entirely satisfactory for the service given these knives, and the hardened zone is sufficiently deep to permit resharpening throughout the life of the piece without necessity of heat treatment.

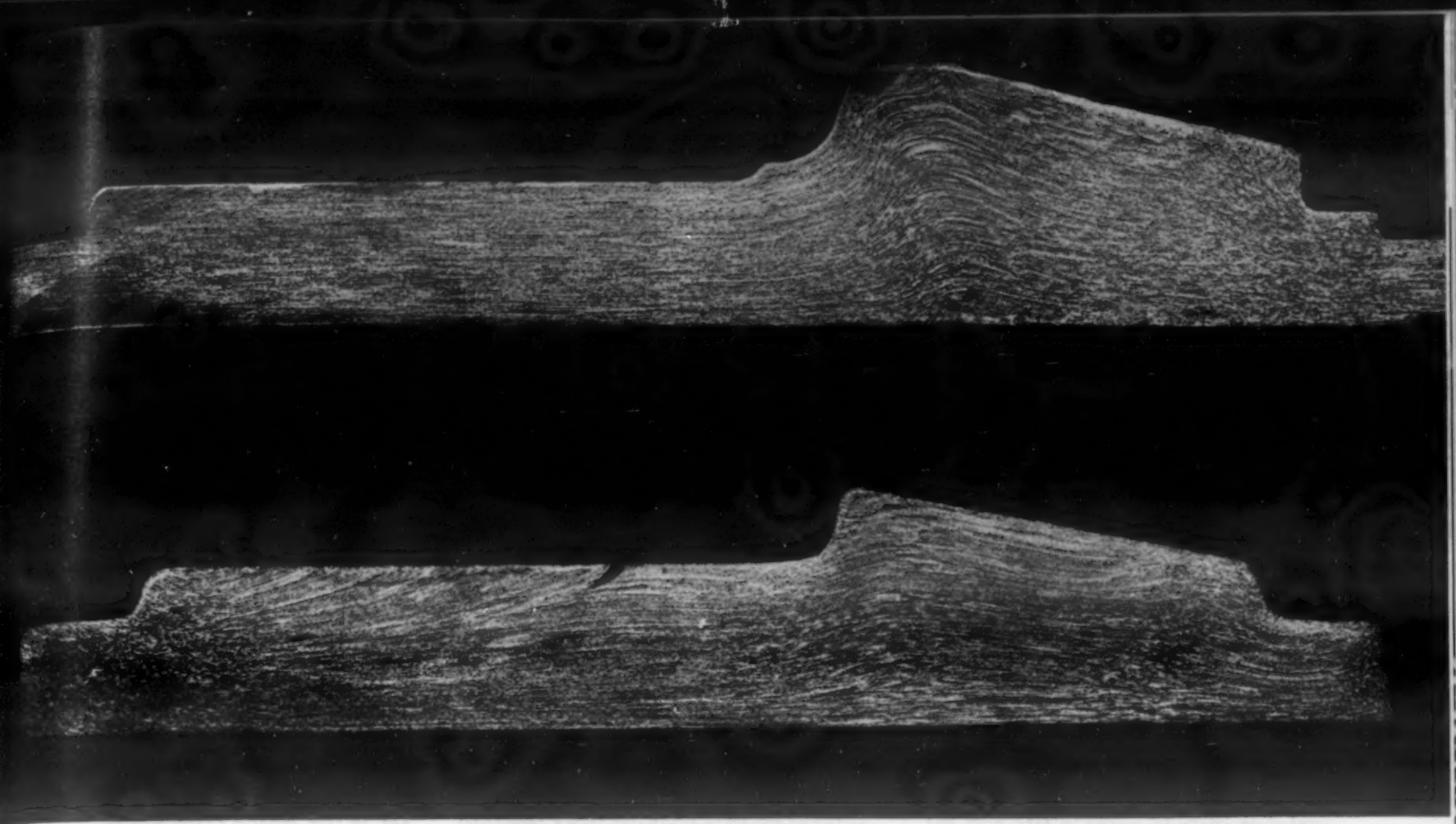


Fig 1—Macro-etching has revealed the flow lines produced in these forgings, enabling the determination of defects in grain flow caused by poor design.

Intelligent Testing and Inspection of Forgings Assures High Quality at Lower Cost

by **LESTER F. SPENCER,** Chief Metallurgist, Landers Frary & Clark

Dimensional checking, metallurgical examination, and physical and nondestructive testing are all useful for evaluating forgings during manufacture.

• METALLURGICAL EVALUATION of processes and products is becoming an essential and generally accepted procedure in the forging industry. By detecting defective material before production operations are wasted on it and determining whether operational procedures or the materials themselves are responsible for failures to meet specifications, intelligent evaluation can result in better product quality and lower cost per item.

Actually, metallurgical evaluation can be practiced to advantage during any or all of the different phases of manufacture and should include inspection of the incoming raw material (both forging and die stock) and the final product. Dimensional checks, periodic inspection of temperature measuring devices, and examination of the physical properties of the material being processed all contribute toward more efficient production and the improvement of the finished product.

In addition, "follow up" studies and comparisions of different processes based on thorough metallurgical investigations pave the way toward better understanding of problems which arise in subsequent operations.

Laboratory Control

Metallurgical and chemical specifications for the purchase of raw materials and the rigidity of laboratory control of incoming forging steel analyses depend primarily upon the quality required in the finished product.

Specifications are actually established on the basis of such factors as: (1) type, magnitude and direction of design loads and the possibility of reversals in stress, (2) workability of materials with both existing plant equipment and accepted processing procedures, (3) metallurgical characteristics of material to obtain the desired physical, chemical and mechanical properties in the finished product, and (4) a thorough study of service records which indicate not only the type and severity of usage in the field of application, but the cause of reported failures and subsequent recommendations for their elimination.

Laboratory control itself can consist of such test procedures as chemical analysis of both the major elements and impurities generally regarded to

Fig 2—Rejected after a visual inspection, a lot of type 440C stainless steel was examined under a microscope, with the results shown here. Heating for forging had caused extremely large grain growth and distinct intergranular weakness. (X 500)

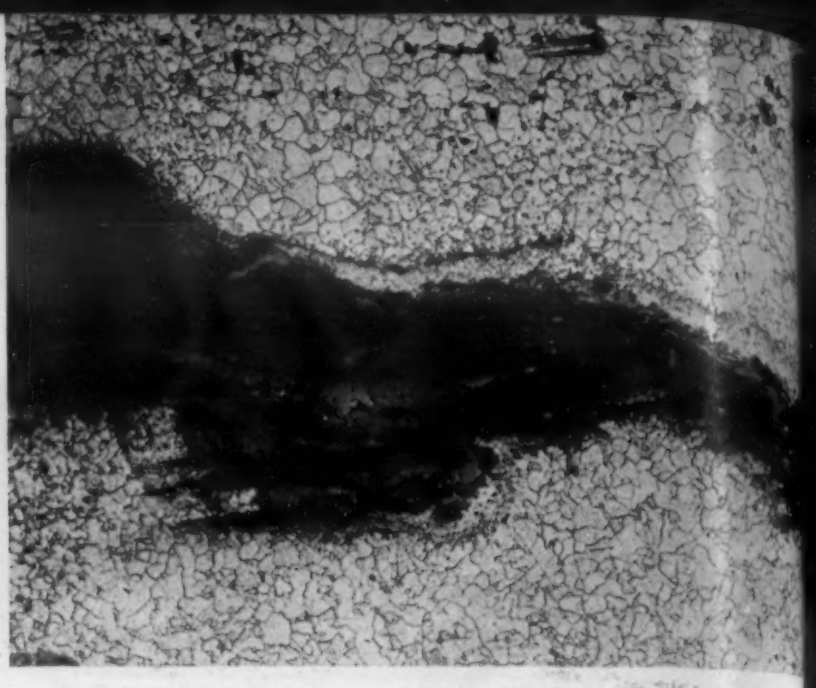


Fig 3—This defect in a ring gear (X 100) illustrates excessive decarburization. Dissolved and reprecipitated oxides in the vicinity of the fault indicate a localized overheating condition.

be harmful; macro-etching for structure or nonmetallic segregations; micro-examinations for such properties as carbide particle size and distribution, cleanliness and grain size; corrosion resistance under selected corrosive media; hardenability; and determinations of mechanical properties.

In the forging of cutlery, surgical instruments and scissors, for instance, the selection of steel should be made on the basis of corrosion resistance, hardenability and/or workability. When corrosion resistance alone is considered, a stainless ferritic grade such as type 430 or a martensitic grade like stainless type 410 or 414 should be specified. If both hardenability and corrosion resistance are desired, either stainless type 420 or any of the stainless type 440 series is preferable. Finally, where hardenability alone is the prime factor, there is a wide selection of low alloy and carbon steels, the choice of which is usually determined by a thorough examination of service records and the acceptability of various types by the trade.

In the aircraft industry, where quality standards are more rigid and well defined by the consumer, selection of the proper steel composition is of the utmost importance because of the low safety factors usually employed to obtain a weight advantage.

For this reason SAE 1040 steel is usually used for crankshafts, propeller shafts, connecting rods, gears, propeller blades, and other parts. This nickel-chromium-molybdenum steel is one of the most reliable of the oil hardening types from the standpoint of uniform machinability, adequate hardness penetration, and comparative freedom from distortion. Similar high-alloy steels are used for either carburizing or nitriding operations.

Laboratory acceptance test procedures in the aircraft industry are rather elaborate. Chemical analyses are performed on bars or billet stock, and are followed by metallurgical examinations which include macro-etching, microscopic tests for cleanliness and grain size, hardenability checks, and tests of mechanical properties. The results are carefully checked with existing standards, and the material, if acceptable, is released for factory usage.

Mechanical Properties

Mechanical testing is one of the more commonly used evaluation tools, not only in the investigation of incoming raw material, but also in the evaluation of the finished forgings and the effectiveness of the various production operations. Results obtained from this testing are compared to standards that have been previously formulated, usually on the basis of product quality demand.

The hardness test is by far the most popular method of evaluation, undoubtedly because of its simplicity of operation and the oft-accepted belief that there is correlation between hardness values and the strength properties of materials tested. Rockwell, Brinell and Vicker testing machines are used to a considerable extent in the check of heat treatment processes.

The tensile test not only provides a quantitative value of both the strength and ductility of the material under test, but also serves as a tool which enables the designer to evaluate and select the material for a specific set of conditions. The more common values obtained in this type of test procedure are the tensile strength, yield strength, reduction in area, and elongation, the latter two items being a measurement, to some degree, of the ductility factor of the material. To the designer, the yield strength obtained at a 0.02% off-set is the prime criterion of the load carrying ability of the material. Where closer values are necessary, an off-set of 0.002% is chosen.

Whenever the size of the forging permits, the test specimen for the tensile test is obtained from extensions or prolongations. If smaller forgings are made or closed-die impressions utilized, the specimen is obtained from one or more forgings in either a melt or a heat treatment group. Location of the test specimen so that a true value of mechanical properties can be obtained is of considerable importance. Actually, it is preferable to locate the specimen in the center of the forging or in the most highly stressed area. In some instances, test specimens can be obtained from a small test ingot taken during the pouring of the steel, or from a portion of the billet used to make the forging. These coupons should receive approximately the same amount of working and the same heat treatment as the forgings they represent.

Many steels that are not hardenable in larger sections become fully hardened in the small test ingot form. For this reason, the values obtained on small sections are only true on large sections where there is complete hardenability.

Bend Test

This test is ordinarily required by various forgings specifications, the degree of bend usually being 180 deg around a pin of predetermined size. According to ASTM Specification A243-43 on ring and disk forgings, for example, a pin 1 in. in dia is used on one class of forgings, while a 1½-

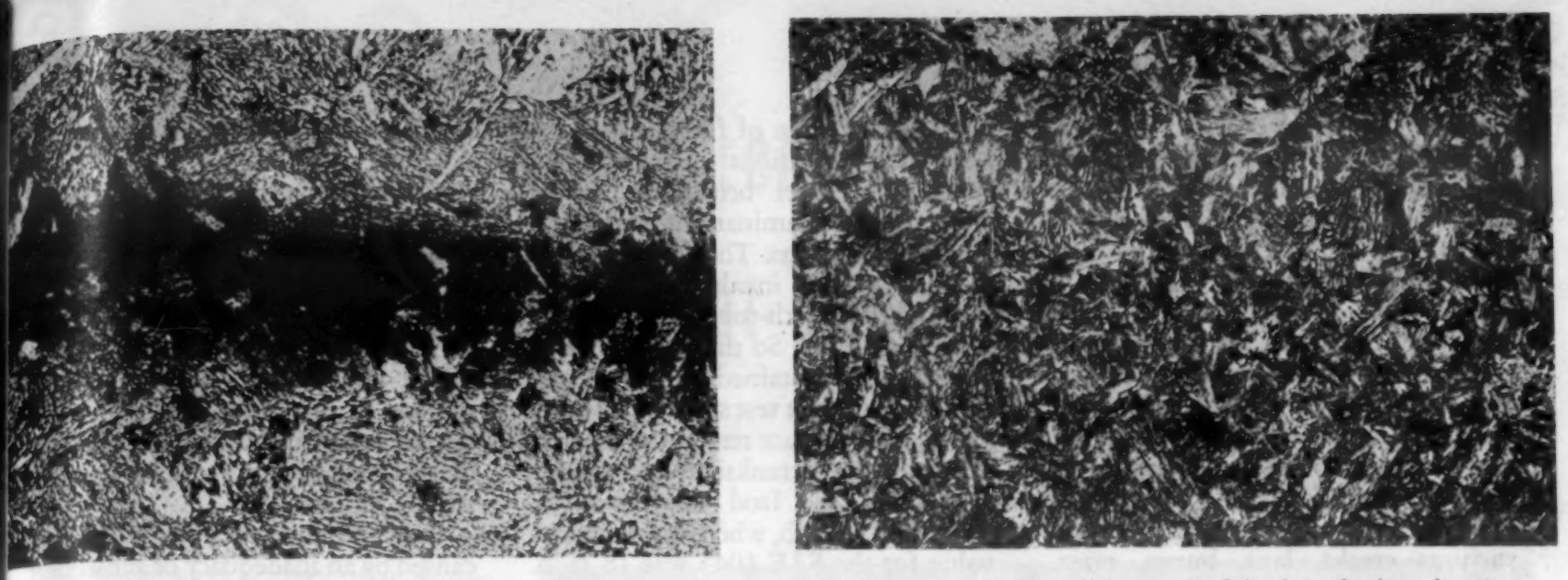


Fig 4—Inadequate normalizing time caused the break and coarse grain structure in the shaft on the left. Lengthening the normalizing time and quenching with water improved the quality of the shaft and resulted in the grain structure on the right. (Both photographs X 100)

in. pin is used on other classifications, usually heat treated forgings.

Fatigue and Impact Tests

Although these tests are not usually required, they are used extensively for evaluation of service on such parts as crankshafts, connecting rods, car axles, gear teeth and pinions. Information on fatigue life is becoming increasingly important, since a large percentage of service failures (with fracturing occurring at a stress which is much lower than the static breaking strength of the material in question) has been traced to a lack of this property.

The fatigue strength at a given number of cycles decreases as the size of the part increases. For example, the endurance limit of a 6-in. dia bar of 0.45% carbon normalized steel may be only 50% that of a 3-in. dia bar. Degree of surface finish has also a marked influence on fatigue life, the number of cycles necessary to cause failure in a rough turned forging being from 12 to 15% less than if it were finished by grinding. Shot peening, if properly performed, may increase the fatigue life appreciably—in some instances as much as 25%. The form factor is also of major importance since few machined parts are of uniform section. Near fillets or oil holes, the rapid change in section causes higher stress concentrations, their magnitude depending upon the extent of dimensional change. These stress concentrations act to further reduce the fatigue strength of the affected part. In the true evaluation of fatigue strength, the factors mentioned above must be carefully considered, since they will temper laboratory results.

This particular point is emphasized in the following test results: a forged NE 8742 and an SAE 1045 crankshaft were tested for fatigue, the endurance limit being 19,000 psi and 17,000 psi, respectively. When specimen bars of material were taken from each of the crankshafts mentioned above, the endurance limit was found to be 73,000 psi and 56,000 psi, respectively. In this example, the test bars were of the R. R. Moore type, using a 0.250 in. critical section. Tests were run on the conventional laboratory machine for such specimens.

Some of the test procedures used for metallurgical evaluation in the forging industry include: macro-etching, metallographic examination, nondestructive testing, hardenability determination, mechanical properties testing, bend tests, and fatigue and impact tests. It is impossible, in an article of this length, to describe fully each of these test methods and its variations. But enough information will be presented in the following paragraphs to give the reader some idea of the scope of metallurgical evaluation.

Macro-Etching

This is a universally accepted method in the determination of such defects as internal thermal cracking or "flaking"; nonmetallic inclusions and segregations; surface defects, like grinding cracks, laps and seams; internal defects, such as pipe, bursts and center porosity; pattern effect; dendritic pattern; and hot decarburization and carburization surface effects. This process consists of submitting a predetermined section size to the action of a chemical reagent whose specific function is to reveal both surface and internal defects. The cross section can then either be visually examined or photographed.

Interpretation of the macro-etched section may be difficult to the uninitiated, although surface seams, internal cracks and pipe are easily recognizable. It is the incorrect interpretation of segregation and dendritic structures, as revealed by deep etching, that may result in expensive errors and needless rejection of material. For instance, every pit does not indicate an inclusion, since pitting can also result from acid attack around carbide particles. Also, irregular etching is obtained if (1) the surface being examined has retained any oil or grease, (2) the surface was prepared by an unsuitable machining method that caused a smearing or rubbing action of the metal, (3) the piece was in contact with other specimens in the etching bath, or (4) the etching solution was contaminated.

Macro-etching is often used to determine flow lines, such as illustrated in Fig 1. In the forging field, it can be used at any point of processing to determine defects in the grain flow caused by poor design. In the finished product, the final orientation of the grain has an important bearing on the physical properties, including resistance to fatigue. Furthermore, during the actual process of manufacture, a macro-etch study will throw a revealing light on the causes of die wear and the reasons for defective forgings.

Metallographic Examination

Microscopic examination is utilized to determine not only the cleanliness of incoming raw material, but the carbide particle size and distribution and the grain size. In the determination of grain size, either the McQuaid-Ehn or the austenitic grain size

method (ASTM E19-39T) is used, the latter being preferred since it takes into account the entire processing in relation to production heat treatment.

Nondestructive Testing

Magnetic particle inspection, used to determine discontinuities, is not only applicable on incoming raw material, but can also be employed in the evaluation of completed forgings. In the latter field, it is recognized as an excellent method for detecting defects such as cracks, laps, bursts, tears, splits, seams, inclusions, segregations, shrinks, laminations, cold shuts and similar discontinuities in ferromagnetic materials.

Zyglo, or fluorescent penetration inspection, is usually associated with nonferrous materials, but can also be applied to ferromagnetic materials. It differs from Magnaflux testing in that the penetrant used will seep into relatively shallow, open discontinuities faster than into deep, but tighter ones. Unlike magnetic particle inspection, fluorescent penetrant inspection is of no value in finding discontinuities that have no connection or opening at the surface.

Use of x-ray apparatus on parts in process and finished goods is becoming increasingly popular. In this method of testing as well as in other nondestructive methods, a specific statement as to type, location and direction of defects must be made and standards laid down for either rejection or acceptance of the product.

Hardenability

The most common method for evaluation of hardenability makes use of the Jominy end quench bar. It involves heating a 1-in. round bar to the austenitizing temperature and then cooling only the end face in a jet of water. Hardness readings are then obtained at intervals of 1/16 in. from the water cooled end.

The Shepherd Penetration-Fracture (P-F) test is also utilized to some extent to approximate the grain size and depth of hardness of forgings. Essentially, it is a comparison of heated and quenched sample sections to a standard.

Unfortunately, the impact test does not supply precise quantitative design information similar to that obtained from either a tensile or a fatigue testing procedure. However, it does possess a remarkable sensitivity which enables one to detect nonuniformities which other mechanical tests do not always reveal. Impact resistance data and the condition of fracture will reveal such conditions as over-heated structure, temper brittleness, coarse segregation or laminations, and other similar conditions. The notch impact test has proved invaluable in determining the notch-toughness of heat treated material. So that reliability of results can be obtained, it is suggested that three impact test sections be used. On an Izod impact test performed on the two forged crankshafts previously mentioned, the Izod value for NE 8742 was 51 ft-lb, whereas the impact value for the SAE 1045 was 18 ft-lb. This is indicative of the value of the alloying elements in the former composition.

Metallurgical Evaluation in Production

In the production of a quality item, it is not only necessary to have procedure control on such items as heating for forging, heat treatment procedures, and forging procedures on such operations as blocking, fullering, rolling, and edging, but it is also important for metallurgical evaluation to establish the cause of rejection of component parts. This latter phase is of extreme importance because it helps to rectify weaknesses in procedure control so that repetition of similar errors will not be repeated.

Such factors as (1) temperature for both heating for forging and heating for quenching, (2) size of furnace loadings, (3) furnace temperature uniformity, (4) furnace cycles for heat treating, and (5) forging sequences all should receive strict attention. In the author's experience, periodic difficulties occur in an evaluation procedure which indicate that one or more of these factors have been inadvertently disregarded. The lack of control of the forging heat is clearly exemplified by a lot of stainless steel, type 440C, which had been rejected prior to completion of forging. Operation was suspended and upon the examination of the objectionable surface appearance and tears, it was found that the furnace temperature had been too high for this critical and sensitive material. Complete metallographic examination of the defect indicated in Fig 2 confirmed this conclusion, the sections examined indicating an extremely large grain growth with distinct intergranular weakness. Fortunately, the deviation from standard practice was found before any large quantity of material was processed. Correction of the furnace practice and maintenance of recommended temperature completely eliminated the difficulty.

Breakage on two ring gears that were forged from a low-carbon, low-molybdenum composition (see Fig 3) was traced to localized overheating in the region of the surface cracks. The forgings had an o.d. of 8½ in. and an i.d. of 4⅜ in. Located on the sheared surface of the internal diameter, the cracks were from 1 to 3 in. in length and extended to a depth of approximately ½ in.

In some instances, difficulties are caused by an inadequacy of subsequent heat treatment procedures. On a forged shaft, for instance, a break was discovered at a fillet where a change in cross-section occurred. Metallographic evidence indicated that a major part of the difficulty was caused by inadequate normalizing time, which prevented the breaking down of grain coarseness caused by the forging temperature. The sequence of operations of the material, Nitralloy G, was as follows: forge, normalize at 1775 F, oil quench from 1750 F, draw at 1075 F, rough turn and redraw at 1050 F. The recommended procedure was principally the same as the original except that a longer soaking time was suggested at the normalize, and a water quench was substituted. A change in fillet design to a more liberal radius was also suggested, since this factor probably had a secondary influence on the breakage. (See Fig 4)

When difficulty in manufacturing procedures occurs in the form of rejectable items, the usual procedure is to trace operational steps from the point of failure to the raw material stock. In instances where the raw material is basically at fault, it is necessary to know both the origin and heat number of the heat in question. This may necessitate segregation of raw material according to heat numbers. If the difficulty is traced to manufacturing operations, corrective procedures should be instituted. It is necessary, however, to follow through with periodic checks to determine the effectiveness of correction.

References

1. Harrison, R. E. W., "The Drop Forging Industry—Looking Ahead"; Chambersburg Engineering Co.
2. "Drop Forging Topics," Drop Forging Association.
3. Pepin, A. J. and Rustay, A. L., "Metallurgical Aspects of Alloy Steel Aircraft Engine Forgings," *Metal Progress*, June 1945.
4. "Metals Handbook," American Society for Metals Publication, Cleveland, Ohio.
5. Macconochie, A. F., "Flow of Steel in Upset Forging," *Steel*, Mar. 13, 1944.
6. "Drop Forging Topics," Vol. 12, No. 3, 1948, Drop Forging Association.

New Zirconia Refractory Material Useful at Temperatures to 4600 F

A NEW MATERIALS PREVIEW

• A NEW REFRACTORY that withstands service temperatures far higher than those at which other commercial oxide refractories can be used has been developed by Norton Co. The material, fused stabilized zirconia, can be used at temperatures up to 4600 F. In addition to resisting high temperatures, the new refractory has amazingly low heat conductivity and excellent resistance to thermal shock.

Although the new material has already found some uses, its full usefulness has not yet been established. However, many chemical, petroleum and metallurgical processes require extremely high temperatures for most efficient operation, and it is in these fields that stabilized zirconia is expected to find widest use.

Applications established already include:

1. Furnace linings.

Gas synthesis furnaces—oxidizing or reducing atmosphere.

Metal melting furnaces—steel, refractory alloys and platinum. Stabilized zirconia tubes and special shapes have been used in contact with molten steel and the metal does not wet or erode the refractory. Other melting applications where low reactivity, low heat loss and high temperatures are required have been proved experimentally. Ceramic kilns—temperatures above 3092 F.

2. Kiln furniture.

One important use is in the firing of titanate parts used in capacitors for the communication industry. The parts are formed and then fired to vitrification at about 2460 F. At this temperature titanates are highly reactive and adhere to all known refractory materials except thoria, beryllia and zirconia.

3. Electric furnace heating elements.

Stabilized zirconia has another characteristic which suggests another application. The material has high electrical resistivity at low temperatures, but becomes an excellent conductor at high temperatures (2732 F and above). The Norton Research Laboratories have built a number of electric furnaces using stabilized zirconia as a heating element in both ultra-high frequency induction furnaces and in resistance furnaces. Furnaces have operated at 4000 F for reasonable periods of time.

4. Thermal insulation—high frequency induction or resistor wound furnaces.

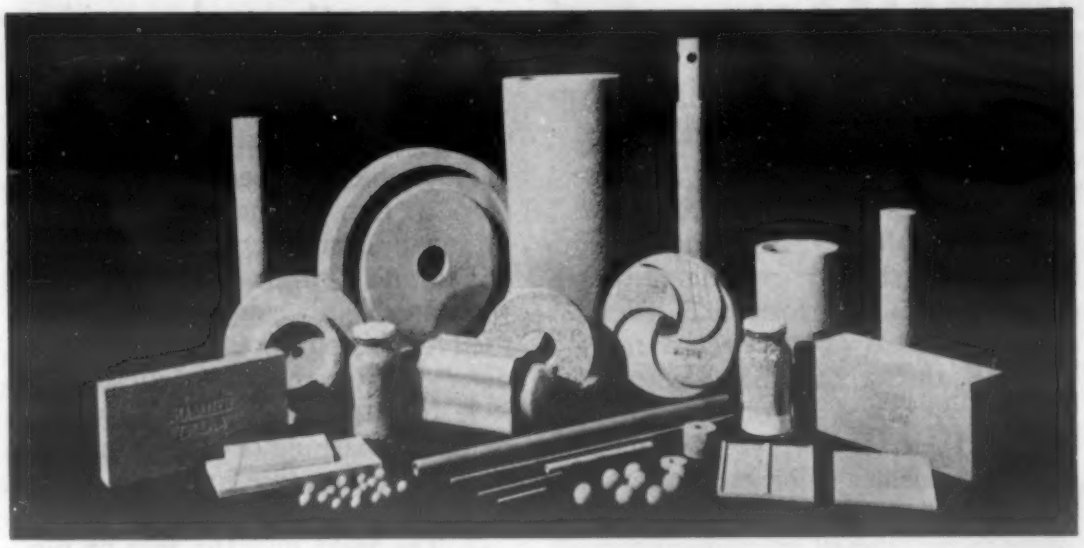
In this application the refractory can be used in shapes or grain as containers and for thermal insulation.

5. Nitrogen fixation—temperatures to 4200 F.

6. Reaction engine parts—jet and rocket liners. These uses are experimental and thus far the information is classified.

The stabilized zirconia refractory is produced in shapes of two types. The first, with a dense structure, is made in standard brick shapes and sizes and in tubes, plates, disks, and many special shapes. The insulating structure (50% or higher porosity) is now being made only in restricted shapes.

Stabilized zirconia is expensive as compared to other commonly used refractories, a fact that will restrict its use to those applications where its characteristics are essential and not equalled by other refractories. A standard 9- by 4½- by 2½-in. brick of stabilized zirconia sells for $9.43. The weight of a standard brick is 16 lb, almost twice the weight of a fire clay brick.



This representative group of fused stabilized zirconia shapes includes bricks, tubes, heat exchange spheres, setter plates for ceramic firing, furnace lining parts, and insulating grain, both light and heavy.

Molded fused stabilized zirconia shapes are formed in presses similar to those used to form metal parts, but pressures used are not as great.

Color-Match Welding Solves Musical Instrument Fabrication Problem

Proper procedures and filler metals produce sound color-match welds in copper-base alloys.

by L. D. RICHARDSON, Eutectic Welding Alloys Corp.

• MUSICAL INSTRUMENTS must be fabricated to exacting specifications and with careful craftsmanship if they are to satisfy the requirements of both appearance and performance. The F. A. Reynolds Co. of Cleveland, famous musical instrument manufacturers, have at last solved a problem that has plagued them for many years—how to obtain a perfect color match in the welds which join the component parts of the many types of brass instruments they build.

A sizable number of component parts go into the manufacture of any brass band instrument, the parts being joined into a single unit by means of welding. The welding alloy that is used for this purpose must really meet diverse requirements as follows:

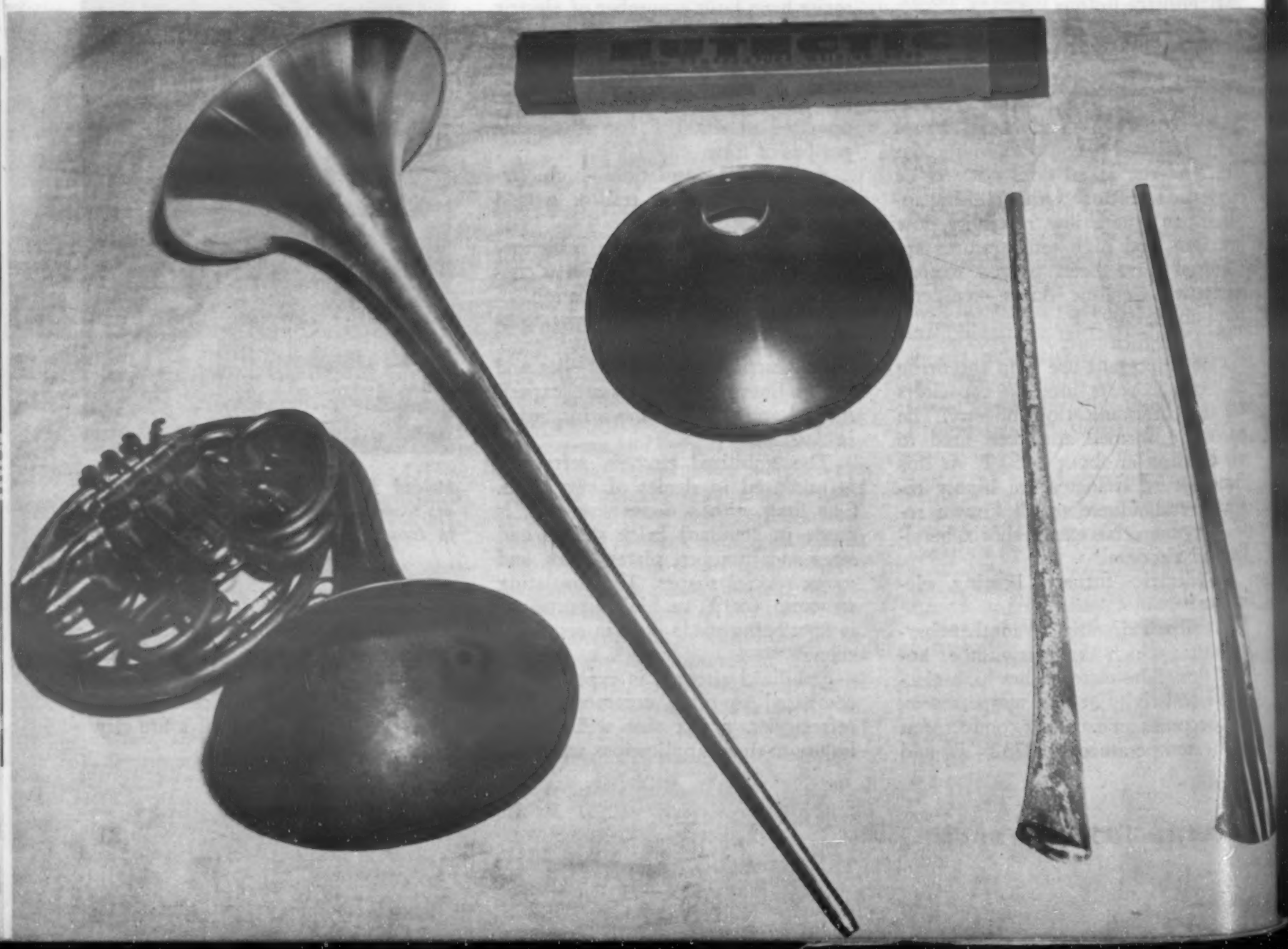
1. It must be applied at low heat, so that no warping or distortion of the parts can take place to impair or destroy the instrument's tonal beauty.

2. The weld must be free of pinholes or other defects, as they would mar the final glossy polish given the instrument.

3. The alloy must furnish high weld strength; after the separate parts are joined, several spinning operations are performed which place very high stress on weld joints.

4. The alloy must perfectly match the color of the base material so that welded joints will not present the visible line of demarcation which would otherwise appear on the finished product, amplified by the high lustre im-

A French horn in the various stages of production (from right to left).



parted to the instrument as a final step.

For yellow brass applications, this manufacturer uses a copper-base alloy rod (EutecRod 18), which gives a perfect color match. Even after the high polish is produced, before the instruments leave the factory, it is impossible to detect the weldments, and the instruments appear to have been fabricated out of a single piece. The procedure used in the mass production of these instruments is rather unusual. The various steps necessary to complete a horn are indicated in the accompanying photograph.

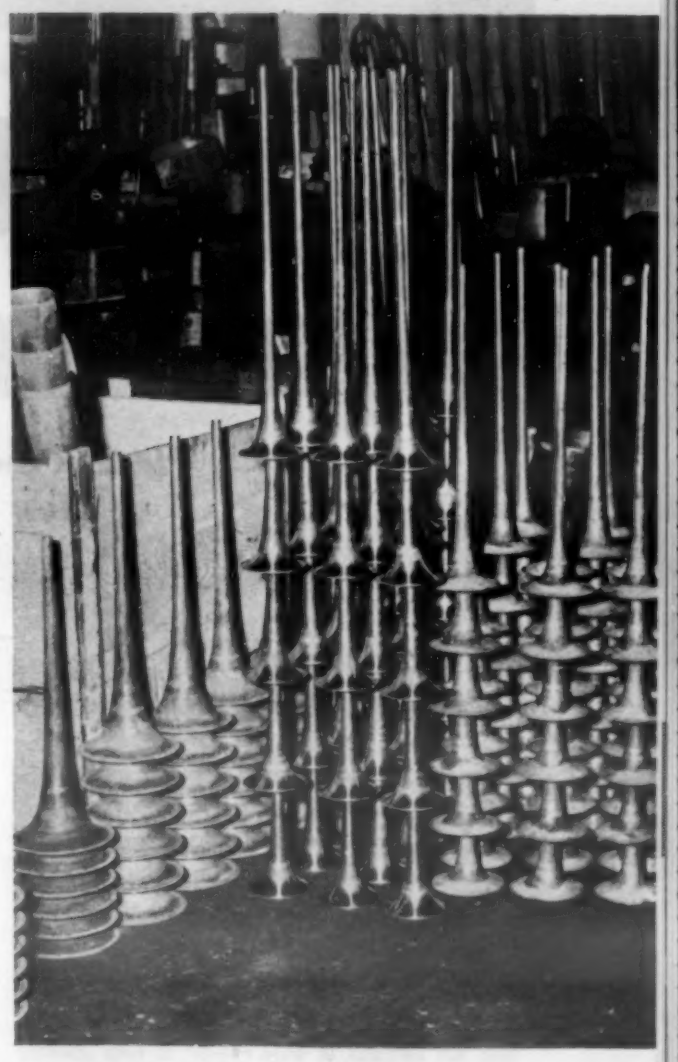
First of all, flat brass sheet is rolled into a cylinder of the desired shape, forming the stem of the French horn. After rolling, the seam is heated with a torch, using city gas and air, and a very large tip so that the flame covers the entire work, and local overheating is thus avoided. A dry powder flux (Eutector Flux 18D) is then sprinkled onto the weld area, to help produce a strong, sound bond, and act as an automatic temperature indicator; when the flux melts, the proper bonding temperature of the rod has been reached. The welding alloy is then applied in 80-mesh powder form, using a spoon to sprinkle it onto the weld area. This area is then heated further until the alloy has completely penetrated into the joint, and the job is complete.

A similar procedure is followed in producing the bell of the horn. The blank, cut out of flat stock, is joined with the same welding alloy, and after the welding operation the bell is spun to the desired shape. It is for this reason that embrittlement of the weldment and the adjacent area must be avoided.

After both the stem and the bell have been fabricated, they are then joined, the welding operations being performed in the same manner as described previously. An accompanying illustration shows the actual welding operation of the stem. Note particularly the large tip and the broad flame employed to eliminate the danger of overheating or burn-through.

Identical procedures, but with different alloys, are used for those instruments which are made of German silver or red brass. A high silver content filler metal (EutecRod 1807), together with flux 1807, is used for color-matched welds on German silver, while a bronze rod (EutecRod 182), with flux 182, is used for the red brass instruments.

Stems after being welded, rolled, joined to bells, and spun.

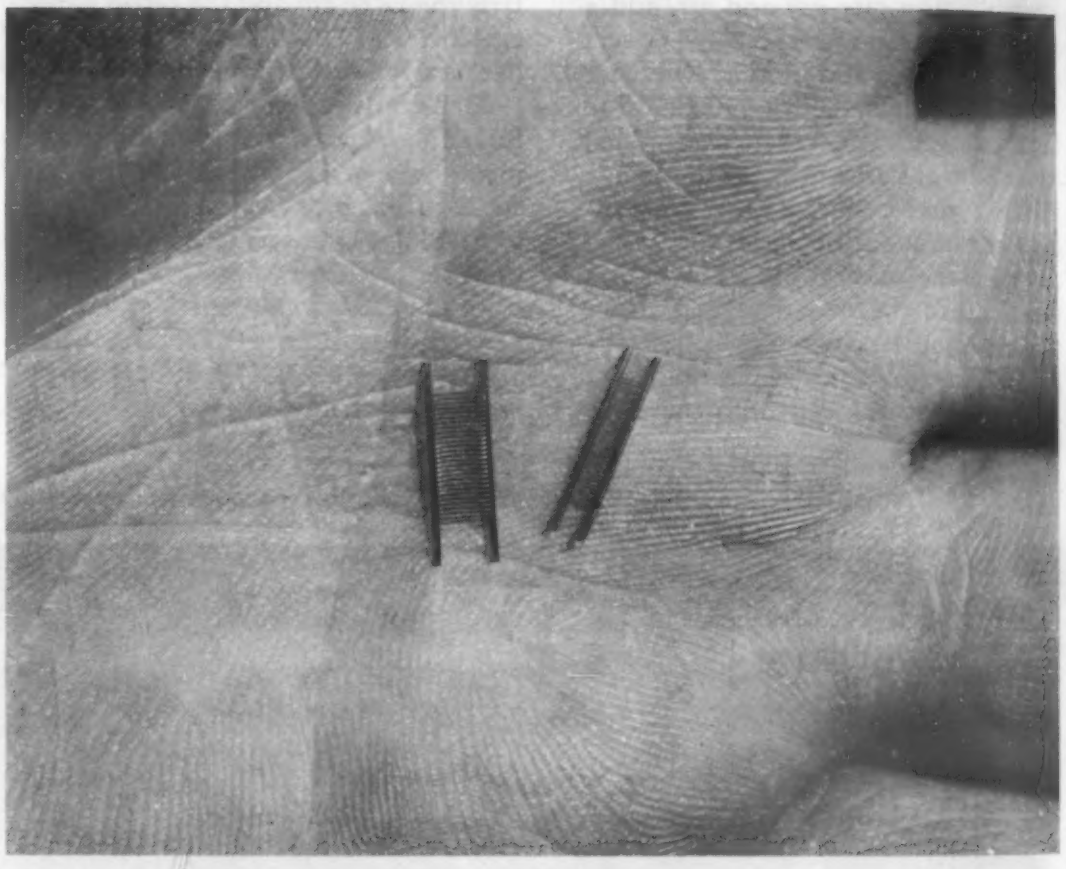


In welding the stem, a broad flame is used to prevent overheating or burn-through.

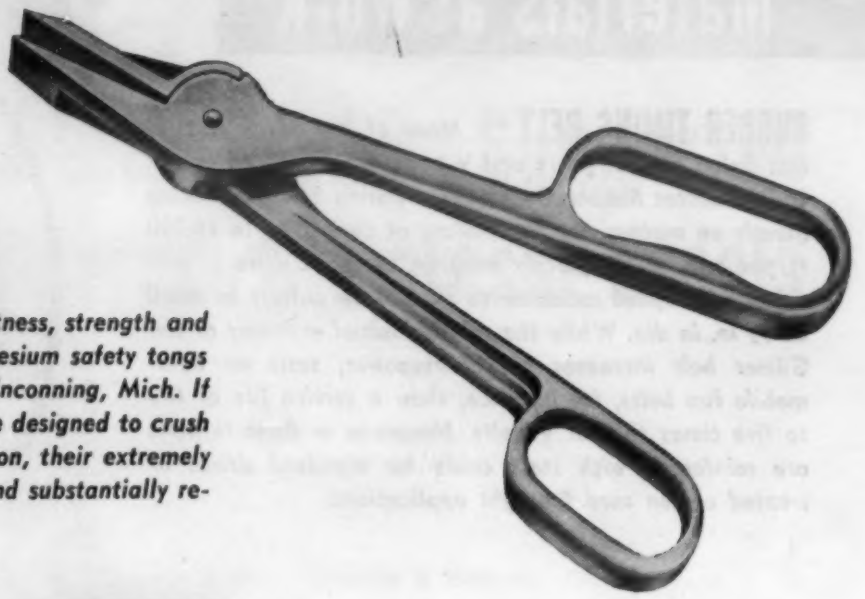
Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .

TINY PENTODE GRID ***Remarkable compactness of the pentode tubes used in the Sonotone hearing aid, made by the Sonotone Corp., is a direct result of nickel's ability to be drawn and rolled into extremely fine gages for grids, plates and supports. Some of these grid wires are less than 1/10 the diameter of a human hair. The strength and ductility of nickel helps in assembly and its election—emissive qualities and other electrical properties give efficiency in the final product.***



ELECTROFORMED NICKEL DIES ***Molds and dies for aircraft parts are electroformed with areas up to 32 sq ft by a process which deposits the metal to a depth of about 3/8 in. on a suitable matrix, usually cast phenolic plastic. The inside surface of the metal shell forms the die. Electroforming saves weight and die-maker labor, and gives better dimensional stability and surface quality than conventional processes. In large molds, pure nickel is stronger, lighter, less easily damaged and more rapidly deposited than iron or copper. On smaller tools, or where maximum rigidity is not required, nickel-copper or nickel-iron construction can be used.***

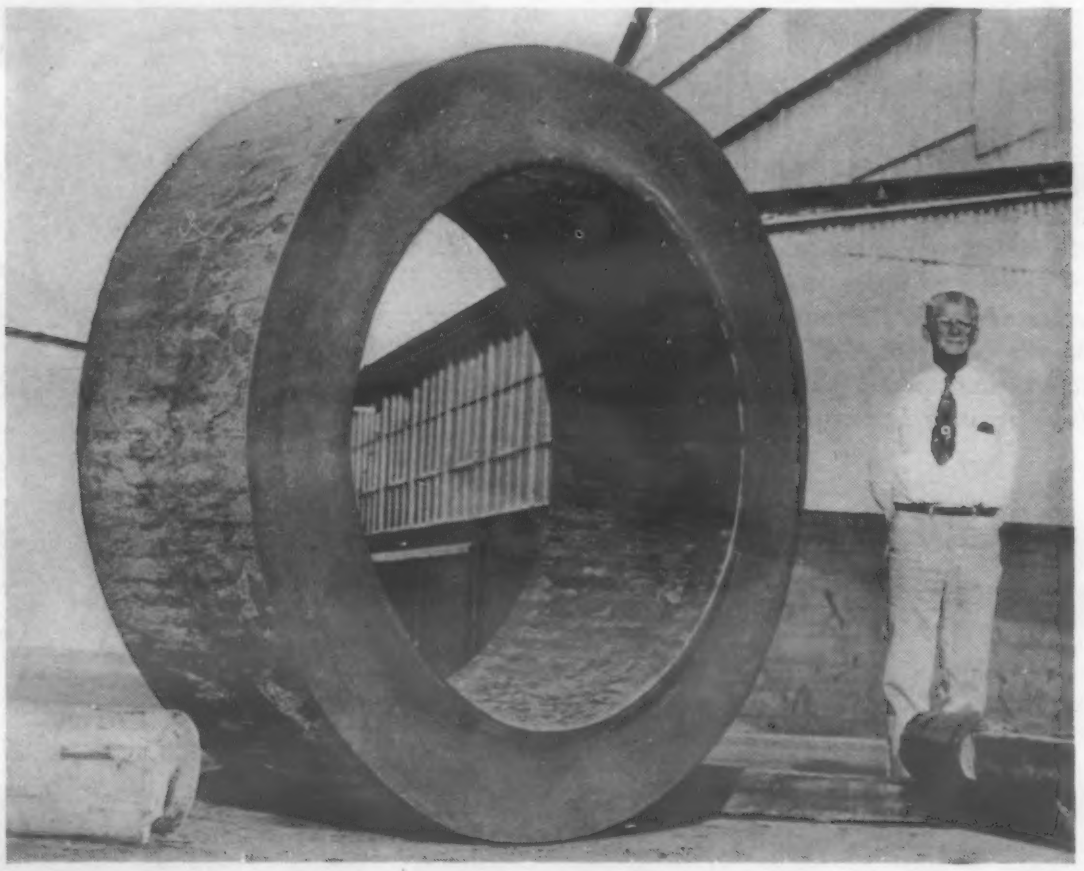


MAGNESIUM SAFETY TONGS

Lightness, strength and rigidity are combined in this pair of magnesium safety tongs recently introduced by Magline, Inc. of Pinconning, Mich. If caught in a die opening, the 6-oz tongs are designed to crush without damaging the die itself. In addition, their extremely light weight permits one-hand operation and substantially reduces operator fatigue.

RUBBER-PHENOLIC HANDLE

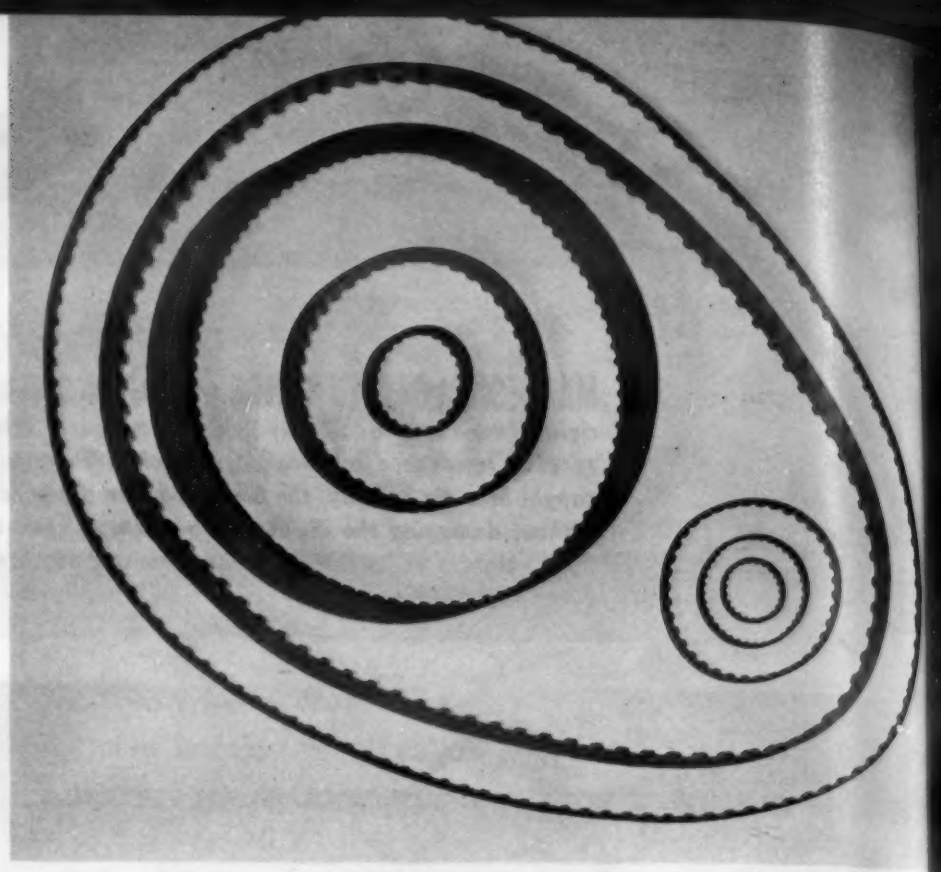
Better machining and tapping and less breakage in assembly and damage in service are obtained in the handle of the Utility Manufacturing Co.'s 100,000-candle-power searchlight by the use of General Electric woodflour-filled rubber-phenolic, with a shock-resistance five to ten times that of conventional phenolics. The handle is molded in two sections, which are held together by screws, and a ½-in. hole is tapped for the insertion of a toggle switch. The resiliency which is attributed to nitrile rubber is obtained without sacrifice of appearance, and the parts are molded without the preforming, molding and finishing inconveniences usually associated with conventional, bulky impact materials.



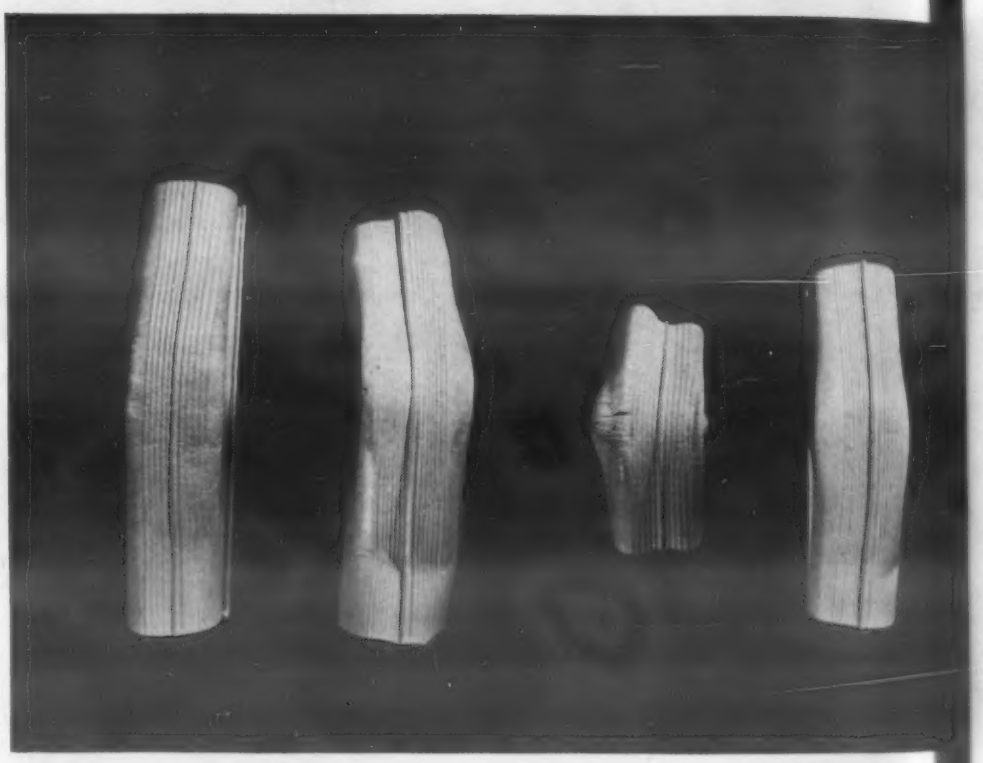
GIANT STEEL FORGING

Weighing 19,000 lb, this ring forging was made at the Torrance, Calif., plant of The National Supply Co. and shipped, with others of equal size and weight, to Inspiration, Ariz., where it will be used as a roll shell for an ore crusher at the Inspiration Consolidated Copper Co. The ring was made by punching a hole in a solid slug of chromium-nickel-molybdenum steel, then forging it over a mandrel.

Materials at Work



RUBBER TIMING BELT *Many of the advantages of flat belts, chains, gears and V-belts are combined in the United States Rubber Co.'s Gilmer timing belts, operating quietly on mating notched pulleys at speeds up to 16,000 ft per min. A completely positive, compact drive is provided, with speed ratios up to 30 to 1 on pulleys as small as ½ in. in dia. While the relative initial economy of the Gilmer belt increases with horsepower, tests on automobile fan belts, for instance, show a service life of two to five times that of V-belts. Neoprene or Buna-N belts are reinforced with steel cable for standard drives or treated cotton cord for light applications.*



PLASTIC REFRIGERATOR GASKETS *Westinghouse engineers have replaced natural rubber gaskets on 1951 refrigerator doors with B. F. Goodrich vinyl plastic, Geon, which is not normally affected by oxidation embrittlement and shows excellent resistance to solvents, oil, fats, waxes and household chemicals. Natural rubber seals require replacement in one to five years, while Geon gaskets have survived 10-year tests. Due to recent price increases of natural rubber, vinyl shows an initial economy as well as a saving in maintenance costs, and the pliability of the new gasket allows more rapid door assembly. The first and third gaskets from the left are natural rubber, the second and fourth Geon vinyl, after a 500-hr stressed light test.*

NICKEL SILVER GAGE POINTER *Accuracy of the inner workings of this pressure gage depends largely on the critical formed radius of the nickel-silver pointer unit (extreme left) where it is engaged by the diaphragm-actuated crank. Rochester Manufacturing Co., producer of the gage, specifies nickel silver because the alloy forms easily, wears well and, most important, retains gage accuracy by resisting creep after forming.*

Substitute Grades Suggested for Scarce Stainless Steels

Acceptable alternates are available for conventional welding grades and nickel-bearing types.

by **KENNETH ROSE**, Western Editor, Materials & Methods

• WITH NATIONAL EMERGENCY regulations beginning to take effect, and with portents of other regulations soon to come, materials engineers find that an important part of their work is the choosing of acceptable substitutes for materials no longer available, or in short supply. Stainless steel, being a highly alloyed steel, is one of the groups of materials to feel the first restrictive orders.

NPA Order M–3, issued effective Oct. 19, 1950, applies to the production, distribution and uses of columbium and columbium-bearing steels. It prohibits the use of columbium-bearing steels, ferro-columbium, and ferro-columbium-tantalum in orders not having DO rating. Furthermore, the use of ferro-columbium is prohibited where ferro-columbium-tantalum is satisfactory, and enjoins against the use of ferro-columbium-tantalum and any ferro-columbium bearing steel in any product or material where any substitute will meet requirements.

Welding Grades

In effect, this order applies to the welding grades of stainless steel that have been stabilized with columbium. Two broad alternatives are presented—to choose a type stabilized with titanium, or to choose a grade in which the composition is otherwise adjusted so that stabilization is not necessary. This latter selection usually means picking a grade in which carbon is held to very low limits, so that carbides cannot form and precipitate. Post heat treatment to redissolve precipitated carbides (heating to about 1950 to 2050 F and cooling quickly to below red heat) will accomplish the same result, but is not always practicable.

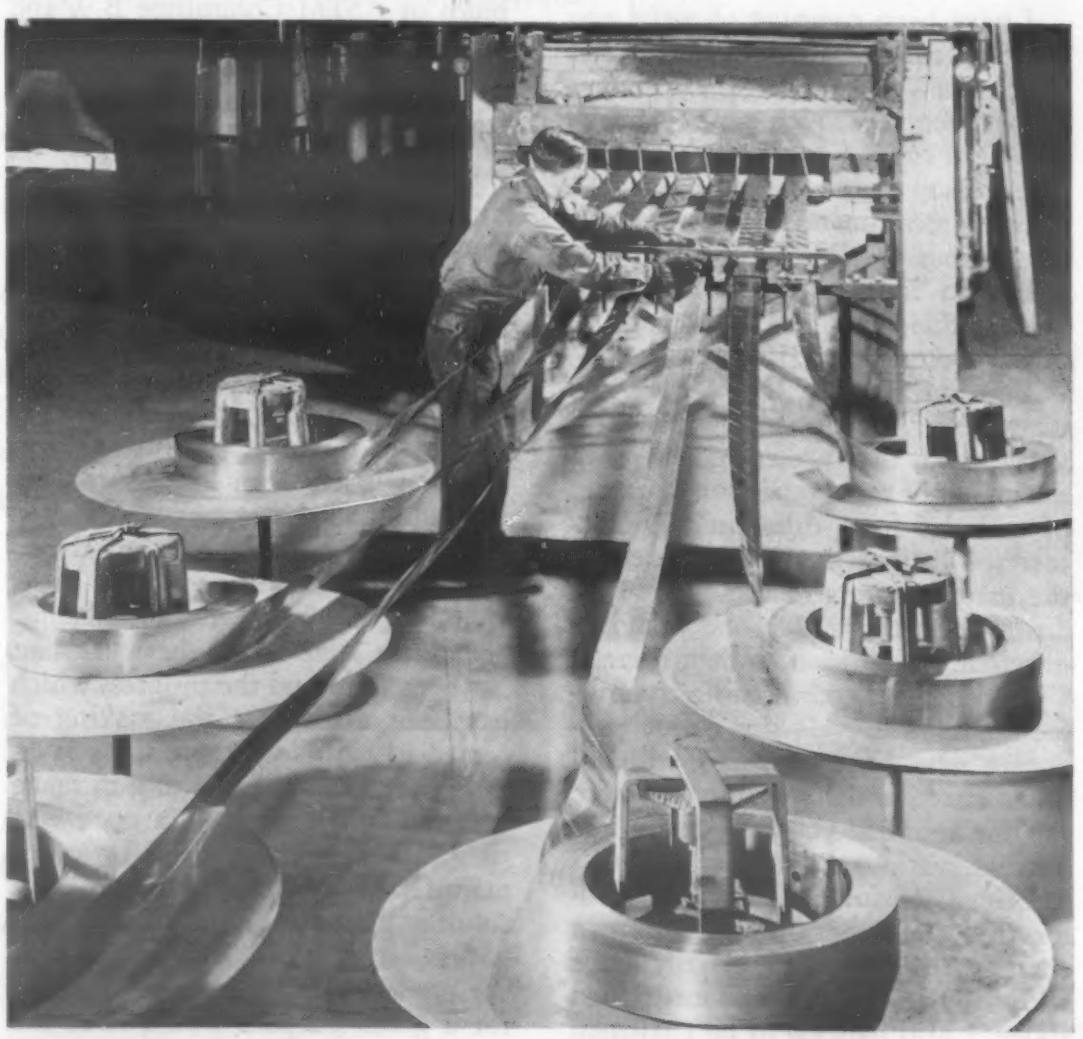
Type 347, stabilized with columbium, can usually be replaced by 430, or by type 321, which is stabilized with titanium. Actually, titanium is thought by some authorities to be a better stabilizing agent than columbium, and it is certainly possible to use less of it to accomplish the same immediate result. Columbium is added in the proportion of eight parts to one of carbon, theoretically. Actually, ten parts are added to be sure of results. Titanium is needed in the proportion of only five parts to one of carbon.

Where service dictates a molybdenum-bearing grade of stainless steel, and the 318 type would ordinarily be chosen, there is a 316 type with quite similar composition but containing no columbium for stabilization. Carbide precipitation is controlled by holding carbon content to a low maximum value. The molybdenum grades are usually chosen for service involving special corrosion resistance, or where high creep strength at elevated temperatures is a condition.

Use of stainless grades in which low carbon content is intended to give stabilization requires two notes of caution, namely:

1. Carbon content must be held to about 0.03% max. Research work done by a leading producer of stain-

Stainless steel, being highly alloyed, was one of the first materials to come under control. (Courtesy U. S. Steel)



less steels reported that the difference in carbide precipitation between steels of 0.07 and 0.05% carbon content is negligible. At 0.03% carbon, maximum improvement in preventing precipitation is marked. It is not usually considered practicable to attempt to hold carbon content to a lower figure in commercial grades.

2. Service should not involve continued exposure to temperatures above 800 F. Carbide precipitation takes place slowly, but long-time exposure to temperatures in the 800 to 1650 F range will permit precipitation in unstabilized grades of stainless steels.

Stabilized grades of stainless steel sometimes show a tendency to crack after being welded, and lower carbon grades may be more satisfactory overall for many purposes.

Nickel-Bearing Grades

Since nickel is and probably will continue to be in short supply, users of stainless steels must also consider substitutes for the grades containing nickel. Nickel is an important constituent in armor steels, in most highly stressed aircraft steels, and in many high-temperature alloys. All of these uses are receiving priority over many of the regular uses to which stainless steel is put.

Of the grades of stainless not using nickel, one of the most important is type 430, with straight 17% chromium. This type is widely used as a replacement for the 18:8 types. When produced with an extra low carbon content, the workability, especially in deep drawing and spinning, seems to show improvement.

The general considerations involved in selecting a substitute for one of the nickel-bearing types of stainless steel are the obtaining of satisfactory corrosion resistance without too great loss of workability. Higher alloy content causes a rapid loss in workability, and lower alloy content brings a loss in corrosion resistance. Thus, such types as 410, having only 12% chromium content, are rarely satisfactory substitutes for 18:8 or other nickel-containing types.

Where the 430 stainless steel is to be used to replace 18:8 alloys, the replacement will be most successful if (1) the corrosive conditions are not too severe; (2) the alloy is frequently cleaned in service; (3) fabricating requirements are not too severe.

Type 430 does not have the corrosion resistance of the 18:8 compositions, and is probably not a satisfactory replacement for many uses in hospital equipment, in the chemical industry, in breweries, and in dairies. Its oxidation resistance is good, and it is suitable for most uses in furnaces, etc. Decorative applications, and such uses as cookware, sinks, counter tops and ice cream cabinets, where the piece is cleaned frequently, can use the 430 material successfully. Where longtime immersion in liquids is a condition of service, there may be some superficial corrosion. Its weldability is limited by its tendency to embrittlement because of grain growth, and drawability is rather poor owing to the lowered ductility of the material. Modifying practice to suit the material should make it a satisfactory substitute where these fabricating methods are involved.

A Letter To The Editor

To the Editor:

I have been meaning to write you ever since I received the December issue of MATERIALS & METHODS but I have been very much on the go with the rapid expansion of our activities. The reason for my writing is the chart on recommended carbide grades for various applications, which was published in your "Materials Engineering File Facts" section on page 85 of the December, 1950 issue.

You and your staff are evidently unaware of the considerable controversy which is at present going on in the matter of the comparison of grades of carbides from different manufacturers. I believe that if you asked all the manufacturers in the carbide industry for a chart, each one would be different. In addition to that, there is a joint industry coordinating committee representing all the major producers who have prepared still another chart, which is different from the one supplied you for publication. Further, various large users such as the General Motors Corp., Ford Motor Co., and others have their own charts which do not necessarily agree with any of the ones mentioned above. I also happen to be chairman of Subsection III-C on cemented carbides of ASTM Committee B-9, and we have had considerable discussion of carbide grade designation charts but have been unable over a period of years to resolve this into any working chart. It is the intention to continue the effort to do so. But this should be sufficient evidence to you that the publishing of any one chart may even be publishing misleading information. For instance, our most important steel cutting composition is our Grade KM, most important, that is, in terms of the quantity we sell, and it has been left entirely off the published chart.

Perhaps some of the technical reasons for the condition which exists would be helpful to you. It still must be said in spite of all the work that has been done and the progress which has been made that the making of cemented carbide compositions is an art. Many of us are working to make it scientific but we have a good way to go. The methods used by every manufacturer are his own and, as a result of variations in individual techniques, it is extremely doubtful if the grades of any two manufacturers for a given purpose would have the same chemical composition even. Since we are dealing with different metallographic structures, different chemical analyses and other variables, it is easy to see that there are no strict equivalents and that one cannot necessarily expect the same performance when switching in the same line of the chart from one manufacturer to another. It has even been shown in some tests that we know of that the differences in performance for so-called identical grades may be as much as tenfold. An article which will give you some insight into this was published in *Metal Progress* in March, 1950. It was entitled "Electron Metallography of Cemented Carbides," by William L. Grube of the General Motors Research Laboratories.

I do not have any suggestion as to what to do now that the chart has been published, but it may merit some note in a future issue pointing out the situation which exists and with which we believe you were unfamiliar.

John C. Redmond
Vice President

Kennametal Inc.,
Latrobe, Pa.

Materials & Methods Manual

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This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

Glass as an Engineering Material

by Kenneth Rose, Western Editor, Materials & Methods

Glass, although it has changed very little fundamentally over the centuries, has experienced many refinements which have widened its field of industrial and engineering applications. High chemical resistance, excellent light transmission properties, high hardness, resistance to abrasion and aging are only a few of the properties that make glass a useful material to the engineer and designer. This manual describes the many types and commercial forms of glass presently available, discusses glass properties and design considerations, and outlines the various methods of glass fabrication.

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Introduction

One of the first truly synthetic materials to be developed by man for the fabrication of things to meet his daily needs was glass. In all the centuries of its history, glass has changed very little fundamentally. It is still a complex mixture of oxides of silicon and certain metals, usually alkaline and alkaline earth oxides. New glasses have been produced that do not fall within this simple definition, but it covers 95% of the glass made today.

Refinements in the manufacture of glass have made it possible to control the color of the material to a degree unknown to the Venetians; demands of industry have brought forth glasses that will transmit or absorb radiations in certain bands of the spectrum, visible and invisible; while special processes have produced glass of high mechanical strength, glass that can be woven into cloth, and glass that conducts electricity. Glass cookware, glass doors, glass cloth reinforcing, lenses for welder's goggles, glass pumps, and self-defrosting windshields are a few of the items that have been produced from these new, special glasses. They have widened the field of industrial applications and the potentialities of the modern version of the ancient material.

The general properties of glass show that it is unique to an extent seldom found among industrial materials. It is the only material of high hardness that can be produced with true optical clarity and in practically colorless form. Until about 20 years ago it was unapproached in the matter of light transmission, but several plastics are now made that will equal the best glass in clarity, though without its resistance to aging and abrasion. It is the only material with practically perfect elasticity up to its breaking strength—that is, it does not take a permanent set under any load short of failure. It shows a tendency toward slow flow, but this is not ordinarily an engineering problem. Glass is really a liquid of very high viscosity, and if a load is applied continuously for a long time—usually many months or even years—it will deform.

The chemical resistance of glass is extremely high, though it is attacked by hydrofluoric acid, by hot concentrated phosphoric acid, and by strong alkalies. It is stronger than an equal weight of steel when fine filaments are being considered, but this strength is considerably decreased, due to notch sensitivity and other factors, when larger specimens of glass are tested. Though frangible, breaking at a blow, glass does withstand steady uniformly applied pressures well. A nonconductor of electricity and a rather poor conductor of heat, it is harder than most metals, and can be fusion welded to itself, and bonded to many metals by special techniques.

Glass can be formed by many methods, some of them peculiar to the material itself. As can be understood from its perfect elasticity, it cannot be cold-formed except by machining or grinding, and the high hardness of the material sharply limits the applicability of both these procedures. Glass is essentially a material to be worked while softened by heat. There are also heat treating methods adaptable to glass.

The two properties of glass most important in providing applications for the material are its transmission of light and other radiant energy, and its high resistance to chemical attack. These two account for such uses as glazing of buildings; railway, motor, aeronautical and marine glazing; instrument dial covers; signal lenses of all sorts; envelopes for lamps and electronic tubes; protective glazing and lenses; gage tubes or covers; filters, prisms and other light-separating devices; and for the vast glass container market of bottles, jars, carboys, etc.; chemical machinery and piping; domestic tableware and cookware; and signs. Other important properties are its electrical insulation, its noncombustibility, and its fabricating possibilities.

Types of Glasses

The principal types of glass, classified according to chemical composition, are as follows:

Fused Silica Glasses

Fused silica—The oxide of silicon can be fused to a clear glass without addition of other oxides, and this material, usually called fused quartz, possesses remarkable properties. Its thermal expansion is so low that it can be heated red hot and then dropped into cold water without cracking. It also shows high mechanical strength, and all told would be an excellent glass if it were not for the difficulty of fusing and fabricating it. The crystalline oxide fuses at 3110 F, and an oxyhydrogen or similar high-temperature flame is required. The absence of other oxides gives the material excellent chemical resistance. When fused to the clear state, it possesses unusually good transparency to both visible light and ultra-violet radiation.

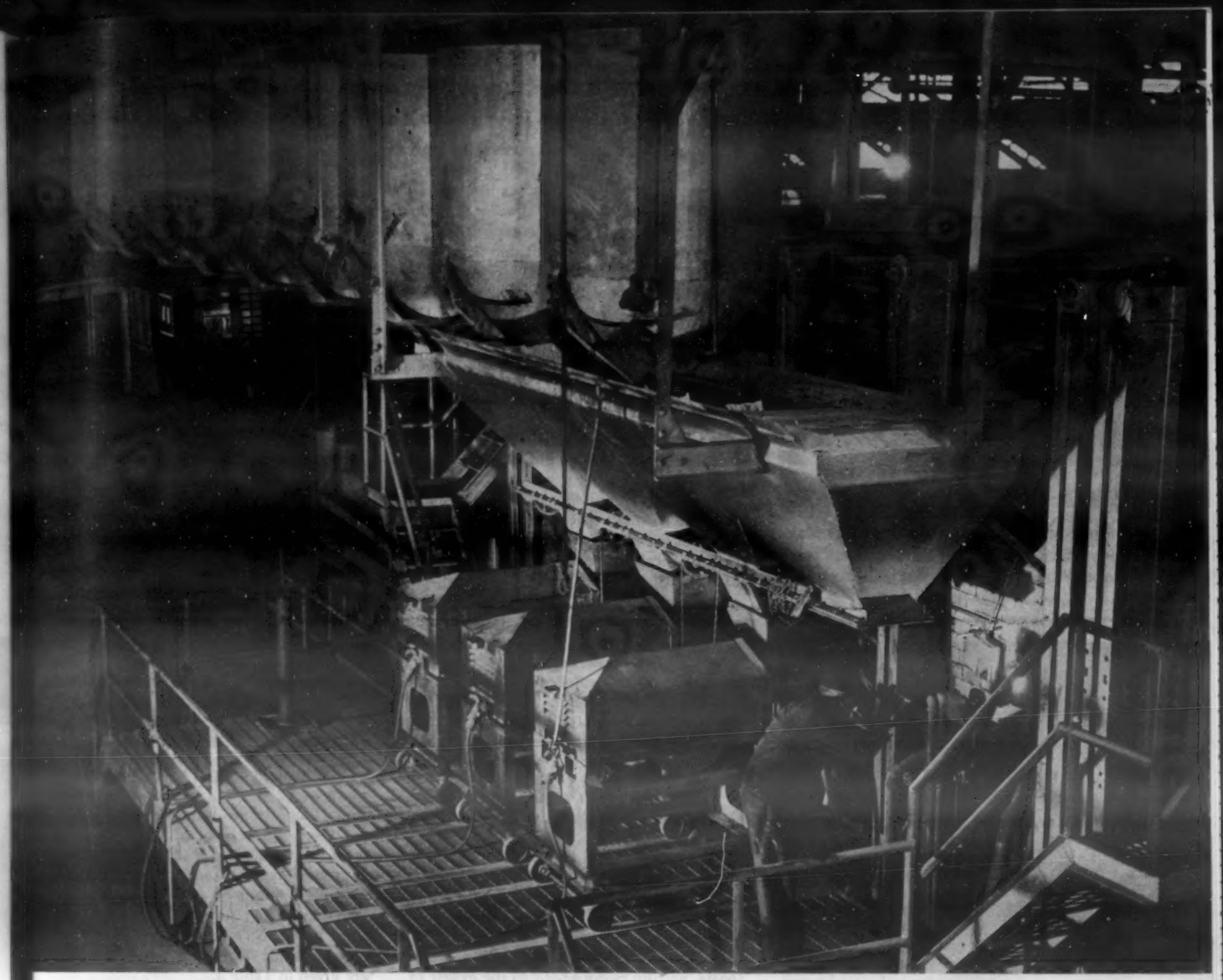
Fused quartz is used commercially in laboratory ware, where its high temperature and chemical resistance properties are of value. It has exceptionally high electrical resistance, and finds some use as an insulator where its other properties also prove valuable. As an industrial material, however, its high cost makes it strictly a specialty to be used where its higher properties will justify the higher price of the material.

96% silica glass—This is really a modification of the fused silica type. Addition of a few percent of another oxide, usually boric oxide, considerably lowers the melting temperature of the silica, and produces a glass that affords some measure of the exceptional properties of the pure oxide along with easier working possibilities. Material of this type offers good chemical resistance, very high resistance to thermal shock, and high strength. Neither the 96% silica glass nor the fused quartz can be heat-strengthened.

While the effect of adding a small quan-

Comparison of Principal Types of Glasses

	Silica	96% Silica	Boro-silicate	Lead	Lime
Cost	Highest	High	Moderate	Low	Lowest
Electrical Resistance	High	High	High	Highest	Moderate
Thermal Shock Resistance	Highest	High	Good	Low	Low
Strength	Highest	High	Good	Low	Low
Hot Workability	Poorest	Poor	Fair	Best	Good
Chemical Resistance	Highest	High	Good	Fair	Poor
Impact Abrasion Resistance	Best	Good	Good	Poor	Fair
Heat Strengthening Possibilities	None	None	Poor	Good	Good
Ultraviolet Light Transmission	Good	Good	Fair	Poor	Poor
Weight	Lightest	Light	Medium	Heaviest	Heavy



Ingredients for glassmaking being fed into a batch melting furnace. (Courtesy Owens-Illinois Glass Co.)

tity of another oxide to the system is to lower the melting temperature of the silica, the production of high-silica ware is approached commercially from another direction. A borosilicate glass of special composition is first produced and formed, and the ware is then subjected to long treatment with acids and heat to dissolve out the alkaline materials (mostly sodium oxide) that have served as a flux during manufacture. The result is a glass having a porous structure and a slightly milky appearance. Heating this chemically purified glass causes the voids left by the acid treatment to close, and a dense glass of good transparency results. Chemically, this glass possesses approximately the following composition: silica, 96; boron oxide, 3; other oxides, 1%. Thus, there is produced, by the forming methods applicable to easier-worked compositions, a glass of final composition approaching fused quartz.

Table 1—Typical Properties of the 96% Silica Glass

Linear Coeff. of Expansion (In./In./°F)	4.2×10^{-7}
Softening Point, F	approx. 2700
Specific Gravity	2.18
Power Factor, 68 F, 1 Megacycle, %	approx. 0.05
Dielectric Constant, 68 F, 1 Megacycle	4.0

Because the product is considerably more expensive than softer glass compositions, it is used mostly for (1) applications in which service temperatures are above 500 F, and up to about 1650 F; (2) uses in which there is high thermal shock; (3) uses requiring high chemical resistance; and (4) for high transmission of ultraviolet radiations. Typical applications are protective tubes for thermocouples, boiler sight glasses, chemical reaction vessels, electrical parts for elevated temperature service, and tubes for germicidal lamps.

The glass after acid treatment and before sintering exhibits very fine porosity, which proves useful in certain types of diffusion of gases, in handling liquids, or in such types of surface reactions as catalysis. It can be formed to a wide variety of shapes before treatment with the acids, giving it an advantage over most of the porous materials available to the chemical industry.

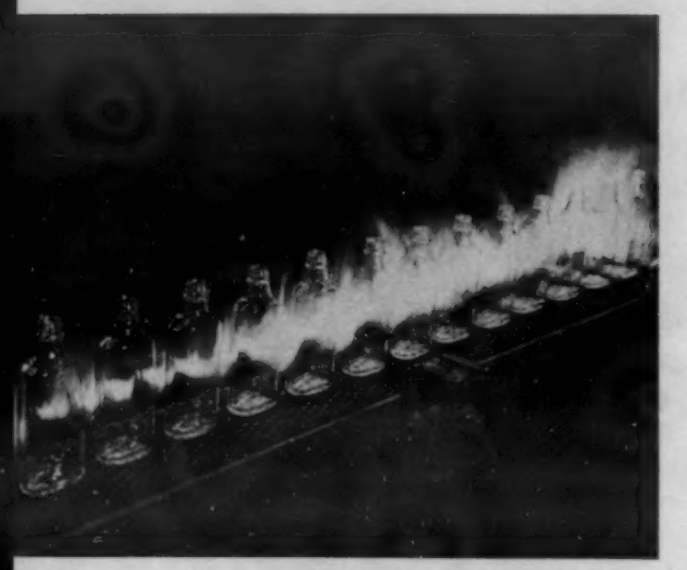
Soluble Glasses

The alkali silicates, especially sodium silicates, are compositions of a glasslike nature that are soluble in water. A mixture of sodium silicates is sold commercially as "water glass," and is widely used as a package adhesive, as a laminating adhesive in the paper industry, and as an ingredient in many other materials. Here again, the addition of the metallic oxide to the oxide of silicon results in considerably lowering the melting temperature of the latter. They have little in common with the other glasses as far as applications are concerned.

Lime Glasses

By far the most important of the glasses in terms of tonnage produced, lime glasses account for about 90% of the glass produced today. They are essentially soda-silica glasses in which lime is added to reduce the solubility of the soluble glass. Glasses produced by the ancients were of this type. In addition to satisfactory physical, mechanical and optical properties, the lime glasses have the advantage of being the lowest in cost. Glass selection, therefore, begins with lime glass, and other types will be chosen over it only if the service requirements demand special properties.

Lime glasses are used for all sheet and



These bottles were formed in a glass blowing machine and are being carried on a metal conveyor belt to the annealing lehr. (Courtesy Owens-Illinois Glass Co.)

Glass gages are being used extensively in industry. They are light in weight, low in cost, noncorroding, and permit greater visibility in inspection.

plate glass, for much of the molded glass produced, especially the lower-priced lines, and for most container glass, while bulbs and tubes for electric lamps are another of the high-tonnage items for which lime glasses are applicable.

Within the group of lime glasses are many formulations, all having variations of the percentages of the basic oxides used —sodium oxide, silicon oxide and calcium oxide. Properties can be adjusted within limits by adjustment of composition. A typical lime glass might have approximately the following composition: silica, 72; sodium oxide, 15; calcium oxide (lime), 9; magnesia, 3; alumina, 1%.

In general, lime glasses have high thermal expansion, and so are rather easily broken by thermal shock; they are somewhat more soluble than most of the glasses, and must be used with caution when chemical resistance is an important consideration; they have poorer electrical resistance than certain other types, notably the borosilicate and lead glasses. In hardness they are above the lead glasses and below the high-silica types. As lime glasses are formulated to possess a wide range of properties, several typical compositions are listed as to properties in Table 2.

Lime glasses in general are not used where thermal shock, high heat resistance, or chemical resistance are required. The highest service temperatures given in Table 2 are for extreme service, where thermal shock is not a factor.

As with all glasses except the high-silica ones, color of the lime glasses can be adjusted to practically any shade by addition of metallic oxides to the molten glass. The oxides are either suspended in the glassy material, or are dissolved in it. Amounts used are so small that the chemical composition of the glass is not materially affected, and physical properties are not changed. Most of the colored glasses produced, except those for which special requirements other than color are demanded, are lime glasses. Opaque and translucent glasses, such as opal glass, are also of this type chemically. Thus, colored glasses for low-priced table ware might be made of lime glass, but if the colored glass were to have a high index of refraction, as for certain types of lenses, or high sparkle were desired, a lead glass might be chosen.

Borosilicate Glasses

This type of glass is an extension of the 96% silica group, in which the percentage of added oxides is increased to about 20%. The added oxides are mostly those of boron, sodium and, perhaps, potassium and aluminum. The oxide of boron predominates, usually being added to the extent of about 14%. A typical composition for a borosilicate glass is as follows: silica, 80; boron oxide, 14; sodium oxide, 4; aluminum oxide, 2%. Composition can be varied within rather narrow limits, and a family of glasses is available in which there are special formulations for high temperature use, for electrical applications, for sealing to metals, and for best strength.

The borosilicate glasses have the lowest softening point of any of the compositions so high in silica. This greatly increases their workability, while at the same time the high silica content confers some of the beneficial effects of high strength, high chemical resistance, high electrical resistance and low thermal expansion upon these glasses. They have only about one-third the thermal expansion of the lime glasses, giving them considerable resistance to heat shock. Because of these valuable properties, the borosilicate glasses are of special importance as industrial glasses for mechanical parts. Properties of some typical formulations are given in Table 3.

Borosilicate glasses find industrial applications as sight glasses, gage glasses, heat protection shields, induction welding jigs, electrical fuse tubes, heat exchanger tubes, electrical insulators, and solder wipers. They are also widely used for laboratory glassware, for industrial piping systems of glass, and for glass cookware. The high chemical resistance of these glasses has given them a place in the container field for the shipping of weak alkalies, many kinds of medicinals, and delicate chemicals. A glass of this group was chosen for the manufacture of the 200-in. telescope mirror for Mount Palomar, the selective factor here being its low coefficient of expansion.

Lead Glasses

In the compositions of this series, lead oxide is added to the sodium oxide-silicon oxide combination. The amount of lead oxide can range from a few percent to as much as 92%, the highest amounts going into compositions intended for protective purposes against x-rays. A formulation with this amount of lead is about as heavy as iron. A typical composition for a utility lead glass might be as follows: silica, 68; lead oxide, 15; sodium oxide, 10; potassium oxide, 6; calcium oxide, 1%. Properties of some of the standard formulations are given in Table 4.

In these glasses the lamp tubing composition is a potash-soda-lead glass. The material for thermometer tubes is also a potash-soda-lead type, and the easy sealing glass, also used for its electrical properties, is a high-lead formulation. A glass of the lead type is selected for the lamp tubing, and especially for fluorescent lamps, because of its excellent electrical resistance, and for thermometer tubing because of its excellent hot workability.

The special properties that permit lead glasses to serve better than the other glasses in certain applications are their exceptional electrical resistance, their high refractive index and high dispersion, and their easy workability. The very high surface resist-

Table 2—Properties of Typical Lime Glasses

Property	General Purpose	Hard Lime (Cookware)	Soda Lime (Lamp Bulbs)
Linear Coeff. of Expansion (In./In./°F)	45 x 10^{-7}	23 x 10^{-7}	51 x 10^{-7}
Highest Service Temp. (Annealed), F	840	1200	860
Highest Service Temp. (Tempered), F	480	840	480
Normal Service Temp. (Annealed), F	230	400	230
Normal Service Temp. (Tempered), F	430	750	430
Specific Gravity	2.40	2.53	2.47
Power Factor, 68 F, 1 Megacycle, %	——	0.37	0.9
Dielectric Constant, 68 F, 1 Megacycle	——	6.3	7.2

Table 3—Properties of Typical Borosilicate Glasses

Property	General Purpose	Metal Sealing	Low Loss Electrical	Baking Ware
Linear Coeff. of Expan. (In./In./°F)	17.8 x 10^{-7}	25.6 x 10^{-7}	17.8 x 10^{-7}	20.0 x 10^{-7}
Highest Service Temp. (Annealed), F	550	825	805	860
Highest Service Temp. (Tempered), F	915	455	445	500
Specific Gravity	2.23	2.25	2.13	2.24
Power Factor, 68 F, 1 Megacycle, %	0.46	0.33	0.06	0.28
Dielectric Constant, 68 F, 1 Megacycle	4.6	4.9	4.0	4.7

ance of lead glass has made it a standard composition for television tubes, and for other critical electrical and electronic uses. The high refractive index, which may range from about 1.51 to 2.18, makes it desirable for optical purposes, and it is, therefore, used in spectacle lenses. The high mean dispersion of light gives it a brilliance that makes it the preferred material for art glassware, and for paste gems, while it is chosen for handmade tableware and for etched glass pieces because of its softness and ease of working combined with the brilliance of the glass itself.

Lead glasses are soft and easily scratched, and are heavy, but their other properties are so unusually good that they remain one of industry's standard compositions.

Table 4—Properties of Some Standard Lead Glasses

Property	Lamp Tubing	Thermometer Tubing	Sealing or Electrical
Linear Coeff. of Expan. (In./In./°F)	49 x 10^{-7}	47 x 10^{-7}	51 x 10^{-7}
Highest Service Temp. (Annealed), F	715	750	715
Highest Service Temp. (Tempered), F	——	——	360
Specific Gravity	3.05	2.89	4.28
Power Factor, 68 F, 1 Megacycle, %	0.16	——	0.09
Dielectric Constant, 68 F, 1 Megacycle	6.6	——	9.5

Special Colored Glasses

Most glasses can be tinted by adding minute quantities of certain metallic oxides or other substances, but there are special glasses made to meet rigid optical and colorimetric standards that really constitute a new series of glasses. Typical of these are the glasses made to transmit a high percentage of light in a given band of frequencies, such as lenses for traffic light, for marine or aerial navigation, for beacons of many sorts; glasses intended to transmit a low percentage of light in certain frequencies, such as glazing for trains, buses and planes, intended to reduce heat and glare, protective goggles for welders, lenses for sunglasses; and tinted glass of many shades intended to form a color scheme, as in the tubes of gaseous tube lighting, where the tube provides one color and the light source another to give an overall color effect.

Some of these colored glasses are carefully standardized as to composition and light-transmitting properties, and are known by special names, such as copper ruby glass, gold ruby glass, selenium glass (with cadmium sulfide and zinc oxide added), uranium glass (a yellow material with a distinctive greenish fluorescence), translucent glasses, and opaque glasses.

Special Oxide Glasses

Although of little or no commercial importance, certain of the metallic and nonmetallic oxides, other than those mentioned, form glasses that have special properties. Fused phosphoric oxides form the basis for one of these types. Glasses of this sort, having no silica in their composition, are not affected by hydrofluoric acid. These glasses, however, lack durability. Some of the rare metallic oxides have also been fused to form glasses, but these have been little more than laboratory curiosities. Some of them are expected to show possibilities as material for optical lenses.

Two additional types of glass can be included with these special glasses. One is photosensitive glass, made to be reactive to ultraviolet radiations, and then capable of being stabilized so that the effects of the radiation are retained in the glass permanently. Actually, a photograph can be reproduced in the thickness of the sheet of glass, and by composition changes in the glass itself, rather than by change in a layer of sensitive material adhering to the surface of the glass sheet. Inclusion of very small amounts of copper, silver or gold in the formulation with a stabilizer is the essential in de-eloping photosensitivity. The second is electrically conductive glass, in which a very thin coating, laid down over the surface of the glass as a transparent layer, provides a degree of electrical conductance. There are several of these coatings, of which tin oxide is one.

Both of these special glasses find commercial applications. The photosensitive glass is finding increasing use as an art material, for production of decorative plaques and vases; it is also being utilized for glass gages and dials, for signs and display items, and recently, for glass shield lighting in which the louvers are formed in the glass by the action of light. The electrically conductive glass is used for self-defrosting windshields, for aircraft, for plug-in percolators of glass, etc.

Commercial Forms of Glass

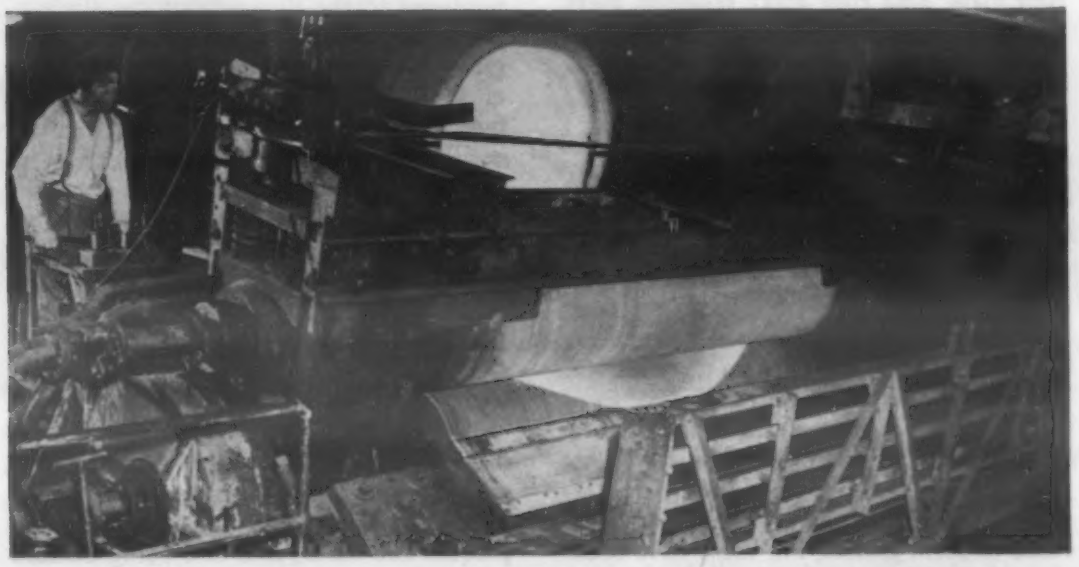
While it is important for the materials engineer to be familiar with the types of glasses, classified according to chemical composition, a classification according to forms produced is even more useful. Glass is produced to finished form by the glass manufacturer in most cases, and industry purchases and uses it as a completed unit to be assembled into a product. Sheet, rod and tube are exceptions, but even here most fabricating beyond simple cutting to size is usually done by an organization connected with the glass industry.

Selection of glass must be made with consideration for both the composition of the material, when special properties are required, and the forms in which glass is produced. Frequently costs can be lowered by careful consideration for form. In such cases the suggestions of the glass manufacturer will be of greatest help.

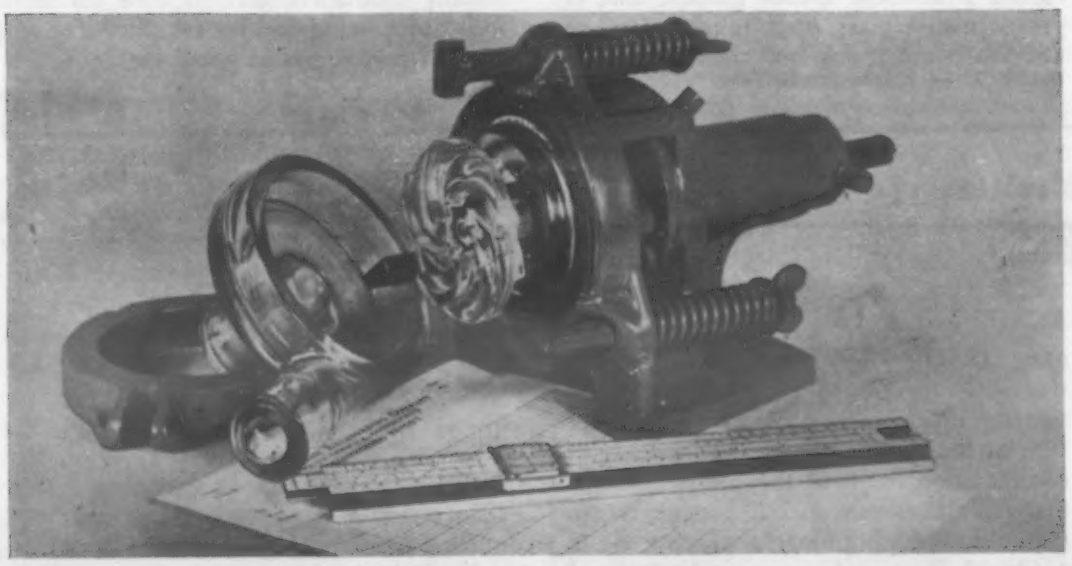
Sheet Glass

Sheet glass is made by extruding a thin strip vertically from the melting tank, permitting it to cool as it descends, then cutting of pieces of the required length from the bottom of the extruded sheet. Special sheet glasses are still produced by casting.

Glass-to-metal sealing using solders and other low-melting metals provide a strong bond. (Courtesy Corning Glass Works)



Molten glass being poured from a giant pot into the rollers of a Bicheroux casting machine. Special types of glass are rolled out in this machine. (Courtesy Libbey-Owens-Ford Glass Co.)



Glass is advantageously combined with metal in this pump. (Courtesy Corning Glass Works and Nash Engineering Co.)

Window glass is a sheet glass of soda-lime composition, produced as a continuous sheet, then fire-polished and annealed. The grades produced today show only slight waviness, and are satisfactory for most glazing of buildings, but will not meet the requirements of state motor codes for automobile glazing, nor are they acceptable for aircraft glazing. It is produced in all thicknesses from very thin to ¼ in. Standard sheets are 76 by 120 in. In addition to glazing of buildings, this sheet is used for table tops, shields, mirrors, electrical insulators, induction heating jigs, and photographic plates.

Tempered sheet glass is the above material, given a heat treatment to set up a stress gradient so that the sheet resists failure in tension better than untreated glass. The glass must be cut to size, drilled or hot-worked before the heat-strengthening procedure is applied. Strength is increased about two to five times. Heat-strengthened glass of this type must be used cautiously where elevated temperatures are involved, or the part may be annealed, slowly or rapidly. Concentrated heat, as long-time use of a powerful lamp with the beam striking one area of the glass, has been known to cause a disk of the glass to drop out of the sheet. Tempered sheet glass is used for gage glasses, safety mirrors, fire screens, business machine windows, hospital glazing, etc.

Wire glass, made by embedding coarse wire mesh in the molten glass, is a type of safety glass. It is usually made with ordinary soda-lime sheet glass, but sometimes a heat-absorbing glass is used to reduce the amount of transmitted solar heat. The wire mesh provides little or no increase in strength, in the glass sheet, but minimizes the danger of fragmentation of the glass after breakage occurs. It is used for skylights, for glazing of greenhouses, for air raid precautionary glazing, and for shields.

Plate glass is produced from soda-lime glass of the same type as window glass, but is ground over the entire surface. It is the only important type of glass, other than optical items, that is finished with a machined surface overall. Plate glass is, therefore, a quality product, and is accepted as of first grade. It is required for certain automotive glazing.

The glass sheet is prepared by rolling, and a knurled pattern is rolled into the glass to assist in the grinding to follow. This first-operation glass is a standard article of commerce in itself, known as *rough rolled* stock. It is produced to a thickness of 3/16 in. to 1¼ in. for the usual grades. Ornamental glazing and obscured windows take textured glass of this type, which admits light but prevents clear vision through the glass.

The rough rolled stock is ground on special grinding machines, then polished overall to a surface that is substantially optically flat. This is *polished plate glass*, usually simply called plate glass. It is used industrially for surface plates, blueprint machines, tracing tables, and the like, and for most sorts of critical glazing, as in the windshields of automobiles; for such architectural purposes as store display win-

dows, counters, doors, stairways and walls.

When additional strength is required, as for gage glasses, pickling tanks, pressure tanks, advertising signs or store front panels, the plate glass may be heat-strengthened. This is sold as *tempered plate glass,* or under any of a number of trade names. Strength is improved to two to five times that of the untreated glass. It must be cut to size, drilled, or otherwise prepared before the heat treatment.

The more important of the special-purpose sheet glasses available are here listed by function. Most of these are special-composition types also, while a few are specially treated after forming to obtain the desired property. The question of whether these specialties are produced as a continuous sheet or as a ground and polished plate is partly a matter of quantity. However, for some applications, such as the heat-absorbing glass in aircraft control towers, the optical quality of plate glass is required. Some of these glasses are produced by both methods.

Heat resisting glass, usually of the borosilicate type, is produced in quantity for heat protection shields, for sight glasses in ovens and furnace doors, electrical insulators etc. Borosilicates can be heat-strengthened, but because of the lower expansion and contraction under change of temperature the strength is not greatly improved. This means, too, that the relaxing effect of elevated temperatures upon the strengthened glass will not cause so great a loss in strength.

Ultraviolet conductive glass is made to a special formulation, as described in the section on compositions. There are several types of high-silica glasses that will conduct high percentages of solar ultraviolet radiation, and these find use largely on the basis of price and requirements. For the covering for a germicidal lamp, a 96%-silica glass can be used, as the amount needed will not be large. For special glazing, as for hospital sunporches, greenhouses, poultry houses, etc., a composition that will pass about half of solar ultraviolet is satisfactory and much cheaper. Ordinary window glass transmits about 10% of ultraviolet radiation.

Document glass is a glass specialty intended to reduce the amount of transmitted ultraviolet radiation. Produced in sheets about ¼ in. thick, it is used in museums for the protection of old documents, collections and displays of a perishable nature. Water white glass is a composition made to exceptional whiteness, and with very high transmission of light. Transmission of visible light may be about 99%. As a sheet glass it is used for greenhouses, for photographic purposes, for picture glazing, etc., while when made with ground and polished surfaces it finds use in photographic and blueprint equipment, in refrigerated showcases and display windows.

Light-reducing glass is a tinted formulation, usually blue or bluish, intended to cut down the amount of transmitted sunlight. It is used in buildings for glazing in sunny climates.

Heat-absorbing glass is another blue or greenish-tinted material, intended to reduce the transmission of heat while admitting most of the light. Glazing with this glass is extensively used for buses, railway cars and airport control towers. It transmits about 70% of solar light while passing only about 45% of the heat radiation.

X-ray protective glass, a heavily leaded glass, is produced in thicknesses of about ¼ in. Its high content of lead oxide makes it a good protective material against x-radiation. It is available in several formulations covering a range of percentages of lead oxide, with corresponding efficiency in blocking out the radiation. A sheet containing 61% of lead, and with a specific gravity of about 4.5, has a lead equivalent of about 0.32. It is used for protection of operating personnel in x-ray laboratories, especially at points where it is desirable to be able to observe operation of equipment while being protected.

Colored glass is obtainable as sheet or plate, transparent or translucent, and in a wide range of colors, plain or varigated. The range of types available as stock items is smaller in the plate glass than in sheet. Colored glasses are widely used for decorative uses of many sorts—ornamental signs, modern furniture, ornamental glazing, special panels, decorative mirrors, and bulletin boards.

Figured glass has an ornamental figure rolled into the surface while softened by heat. The figure can be any of a variety of patterns. The glass is used to diffuse or otherwise reduce the amount of transmitted light. It finds application in the glazing of skylights, for panels over indirect lighting, for obscured windows, and for many kinds of glare-reducing applications.

Polarizing glass consists of sheet glass coated with an organic crystalline chemical that polarizes the light transmitted. It is used for such antiglare applications as sun glasses and sun visors.

Electrically conductive glass, one of the newer developments in sheet glass, is another coated material. The coating is a very thin layer of a semiconductor, such as tin oxide, that permits transmission of light and also conducts the electric current. It is used for self-defrosting windshields on military aircraft, for similar windshields on automobiles, etc.

Photosensitive glass was announced several years ago, and is now beginning to find industrial applications. It consists of ordinary glass, usually of a lime-soda type, to which very small quantities of photosensitive materials are added at the time of making the glass. The glass is exposed to a high concentration of ultraviolet light, through a photographic negative or other pattern, the glass is "fixed" or stabilized, and the image is permanently formed in the glass. The material is used for decorative plaques, for graduated gage glasses, and for louvered glass sheets over indirect lighting.

Laminated Glass

Laminated glass, or safety glass, is made by sandwiching a transparent plastics bonding agent between each of two or more layers of glass, the interlayer of plastics material preventing the splintering of the composite if broken. The interlayer is a vinyl plastic, frequently polyvinyl butyral. By using any of several types of glass, along with variations in the type or coloring of the interlayer, the completed laminate may achieve a considerable degree of flexibility in properties.

Safety sheet is made by laminating two or more layers of ordinary sheet glass. Thickness of the finished laminate, using two layers, is usually from $\frac{3}{32}$ to ½ in. It is used for railway car windows, protective shields, bus glazing, etc. This is the lowest-cost laminate.

Heat-absorbing laminated sheet is made with heat-absorbing glass, and has the added advantage of reducing the amount of solar heat transmitted. It is used in bus and railway car glazing.

Tempered laminated glass is made with one or more layers of heat-strengthened sheet glass. The pieces must be cut to size before the heat-strengthening and laminating operations. Glass of this kind is used for protective shields, jewelry store windows, etc.

Safety plate is used for automobile windshields, for aircraft windshields, for safety lenses, and jewelry store windows. It is made by laminating plate glass in the same manner as other glasses. The composite is usually about ¼ in. thick. Most automobile glazing uses safety plate for the windshield, where state motor codes require best optical properties, and safety sheet for side windows.

Bullet-resisting glass, made with sheet or plate, is produced in standard thicknesses of ½ to 1½ in. It consists of several layers of glass, usually three, laminated in the same manner as for other types. It is intended primarily for protection against firearms, and is used in glazing for banks, police cars, and money collecting trucks. Glass of this type is sometimes made with heat-strengthened layers also. In addition to its primary use for bullet protection, it is sometimes used for glazing of cabs of cranes where the danger of falling objects is great.

Tinted safety plate is one of the newest of the laminated glasses. It is used for the windshields of several makes of automobiles. Here the glass layers in the composite are of the usual plate, but the plastics interlayer is tinted with a gradation in the shade from deep bluish-green at the top of the windshield to colorless at about half the height. The gradation reduces the sky glare while permitting unimpaired vision of the road.

Double glass is not laminated in the same way as the other glasses of this group. Two layers of glass are cut to dimensions, metallized around the edges, soldered to a spacer, and evacuated of air. The space can be filled with nitrogen gas, and desiccant is added to remove moisture. The composite is then sealed, and is ready for use. In some double glass panes another type of spacer is cemented in place by an adhesive bonding.

Double glazing is widely used for air-conditioning buildings, air-conditioned railway cars, and similar applications. It cuts down the conductance of heat through the

pane of glass—an important loss of heat. It is necessary that all moisture be evacuated; otherwise a mist will cloud the glass. The panes must be made to order as to size. Most of the double glazing is done with panels composed of two layers of glass each about 1/8 in. thick, with a spacer of about the same thickness.

Formed Glassware

Formed glassware is discussed in some detail in the section on fabricating of glass, but is briefly listed here for the sake of completeness. Most of these methods are high-production procedures intended for turning out large quantities of a given part at relatively low cost.

Pressed ware is made by pressing glass into a mold, by hand or automatically. Metal inserts can be used with this method. It is widely used for such pieces as godet wheels, glass gages, sight glasses, centrifugal pump parts, electrical insulators, rotary valves, household utensils, and decorative glass articles. Compositions of glass used are selected to suit requirements. Lead glass or soda-lime types are most used for household or decorative ware, while borosilicate glasses are pressed into parts requiring high thermal properties or unusual strength. Many pieces are capable of heat-strengthening.

Blown ware, produced by hand or automatically, includes hollow forms. Parts can be heat-strengthened if of suitable shape. Easy-working soda-lime glasses are most popular, but compositions of better resistance to thermal shock can be used if needed. Bottles, jars and other containers, floats, laboratory glassware, lantern globes, and household glassware are typical of the blown products.

Drawn ware includes tubing, glass pipe, rod and filament. Rod and tube uses soda-lime or borosilicate glass, and filament is drawn from soda-lime composition. Chemical pipe, gage glasses, tubing, and composites made from tubing are typical drawn ware products. The filament is used as:

1. Batts, in which the fine filaments are collected at random in an unoriented, woolly mass. The mass can be treated with a resin binder and compacted to any desired degree. The batts form a nonabsorptive, noncombustible, chemically resistant material with good sound-, heat- and electrical-insulating properties. It is used for insulation of aircraft, domestic ranges and railroad tank cars. In the chemical industry it becomes a tower packing material, and it serves as a sound deadener in test rooms and public buildings. It is finding an application as dust filter in air-conditioning installations.

2. Blocks, made from batts compacted to rigid form by pressure and held with a binder. It is produced in thicknesses to about 2 in., and finds use as an insulator for boilers, breeching, ovens and pipes. Two grades are produced, one suitable for use to about 600 F, the second to about 1200 F.

3. Textiles, in which the filaments are spun to threads and woven to fabric, braided to cord, or swirled to a mat. Woven materials of glass fiber show exceptionally high strength. The textiles are used as a heat insulator in pipe lagging, and over aircraft engine exhausts; as an electrical insulator in the covering for wire, cable and ignition coils; as a decorative, or fireproof or rotproof fabric in draperies, military items, etc. The swirled mat, along with the woven cloth, finds use as a reinforcing material in plastics laminates, and with natural and synthetic rubbers.

Multiformed ware is made with glass powder that is compacted to close tolerances, then sintered. This method of forming is especially useful for producing large pieces. A wide variety of compositions can be used. Electrical insulators, pump coal rings, etc., are made by this method.

Special Structural Forms

In addition to the commercial forms of glass produced by standard procedures, there are a few forms made by methods that do not fit into these groups.

Glass blocks are made by fusing together two halves of pressed glass to form a hollow, partially evacuated block. They are produced in three standard sizes—5 3/4 in. sq., 7 3/4 in. sq., and 11 3/4 in. sq., all 3 7/8 in. thick. The blocks are used for light-transmitting walls, for permanently closed windows in air-conditioned buildings, and for interior partitions, etc.

Cellulated glass is lighter than water as usually made. It is used for noncombustible life rafts, thermal insulation, fishing floats and building blocks. It is made by trapping gas in molten glass to produce a material containing numerous closed cells. It is sold in blocks up to 12 by 18 by 6 in. in size.

Cast ornamental panels. Sculptured designs are cast in glass, and the panel is then given a finishing treatment to accentuate the design. This can consist of frosting the back face by sandblasting, or by polishing, metallizing, etc. There are standardized patterns and designs in strip or square panels. They are used for fountains, for door or fireplace trim, for screens or partitions, strip decoration, etc.

Properties of Glasses and Design Considerations

Strength Properties

Many of the conventional properties used to evaluate other materials, such as metals, either do not apply to glass or must be determined by testing methods so different from the standard that results are not accurately comparable. Mechanical strength, especially in tension, is one of these. It is generally accepted that fused quartz and the high-silica glasses, such as the 96% silica types and the borosilicates, are stronger than other glasses, but breaking strength is still so variable with size, shape, surface condition and method of applying stress, that exactness in fixing values is out of the question.

The breaking strength of a sample of lime glass, determined by bending 1/4-in. rods between knife edges 4 in. apart, loading at the center, and calculated to tensile strength, shows an average of about 11,000 psi. Modulus of rupture of lime and lead glasses might be expected to be of the order of 4,000 to 8,000 psi, and that of the high-silica glasses about 6,000 to 10,000 psi. These figures are not limits, but are intended rather as approximate guides to results that might be obtained with pieces neither excessively small nor extremely large, and without any special surface preparation. It has been mentioned already that tensile strengths determined upon single glass fibers may be as high as those for steel.

In designing for structural use of glass, it is customary to adopt a maximum working stress of 1,000 psi as suitable for annealed glass, and a value of 2,000 to 4,000 psi for heat-strengthened glass, depending upon the shape and character of the piece. These figures provide an adequate safety factor. They are used for all types of glass, though the borosilicate glasses are generally accepted as being stronger than the lead or lime glasses.

The strength of glass in compression is considerably higher—about ten times as high as its tensile strength. Glass always fails in tension. It is for this reason that heat-strengthening, in which compressive stresses are set up in the surface layers of a piece of glass, accomplishes an overall strengthening of the glass. Before the glass can fail in bending, the compressive stresses on the convex side must first be reversed, then carried to failure in tension.

Heat-strengthened glass is most useful at ordinary temperatures, or at temperatures only a few hundred degrees higher. At a temperature of about 700 F the heat-strengthened glass will lose about half its strength the first day, and loss will continue less rapidly thereafter. Blue and greenish glasses, used to reduce transmission of heat, accumulate the heat so rapidly that heat-strengthening of these colors is unsatisfactory. Temperatures at which the various types of glass can be used in the heat-strengthened condition have been given in connection with the listing of the types of glass by chemical composition.

The modulus of elasticity is about 9,000,000 to 10,000,000 psi for most commercial glasses, but special compositions may show values as low as 6,000,000 psi or as high as 13,000,000 psi. The figure of 0.22 may be accepted for Poisson's ratio.

Glass is subject to fatigue, and suffers loss of strength with increasing time under load. Temperature also has an effect. Strength seems to be greater at low temperatures, decreasing with rising temperature to a minimum at about 200 to 350 F, and then increasing with continuing rise of temperature.

Because glass is highly notch-sensitive, surface hardness cannot be determined by methods that will give results comparable to those for metals. It is harder than most metals, however, and may be thought of as being under "file-hardness," but harder than soft steel, aluminum or brass.

Thermal Properties

The expansion of a glass when heated is of considerable importance in industrial glasses, as this is a measure of its ability to withstand thermal shock without breaking. Linear coefficients of expansion (cm per cm per deg C) for some of the important types of glass are:

Fused quartz	5.5×10^{-7}
96% silica glass	7.5×10^{-7}
Borosilicate glass	50×10^{-7}
Heavy lead glass	80×10^{-7}
Lime glass, plate and window	$80–90 \times 10^{-7}$
Lime glass, soft, high alkali	$90–100 \times 10^{-7}$

Thermal stresses set up by variations in temperature and the corresponding expansion or contraction of the glass may be in a steady state with constant temperature conditions, or temporary, with fluctuating temperature. The stress is set up by the difference in temperature between two sides of a glass part, bringing the hotter surface into compression, the cooler into tension. The magnitude of the tensile stress depends upon the expansion coefficient of the glass, the modulus of elasticity, and the temperature difference between the two faces of the glass. Temporary, or transient, thermal stresses increase with the thickness of the glass and the expansion coefficient, and are dependent upon the shape of the piece and the method of chilling or heating.

Tests that serve as guides to serviceability of a glass under thermal stress have been set up. Thermal stress resistance is measured by subjecting the two sides of a tube or constrained plate to a temperature differential, and then measuring the differential that will cause a stress of 1,000 psi on the cooler surface; while thermal shock resistance is determined by heating squares of glass 6 by 6 in. to a uniform temperature and then dropping them into cold water, the maximum temperature differential between glass and water at which no breakage occurs being the index. Results for several standard types of glass are:

	Thermal Stress Resistance, Deg C	Thermal Shock Resistance, Deg C
96% silica	200	1,000
Borosilicate, general purpose	48	150
Lime glass, general purpose	19	60
Lime glass, hard, heat resistant	29	115
Lead glass, for lamp tubing	17	50

The plates for thermal shock resistance were of ¼-in. thickness, and the glass was in the annealed condition. Tempered glass will have about twice the resistance of annealed pieces. Thermal expansion and resistance to thermal shock has also been discussed in the section on types of glass.

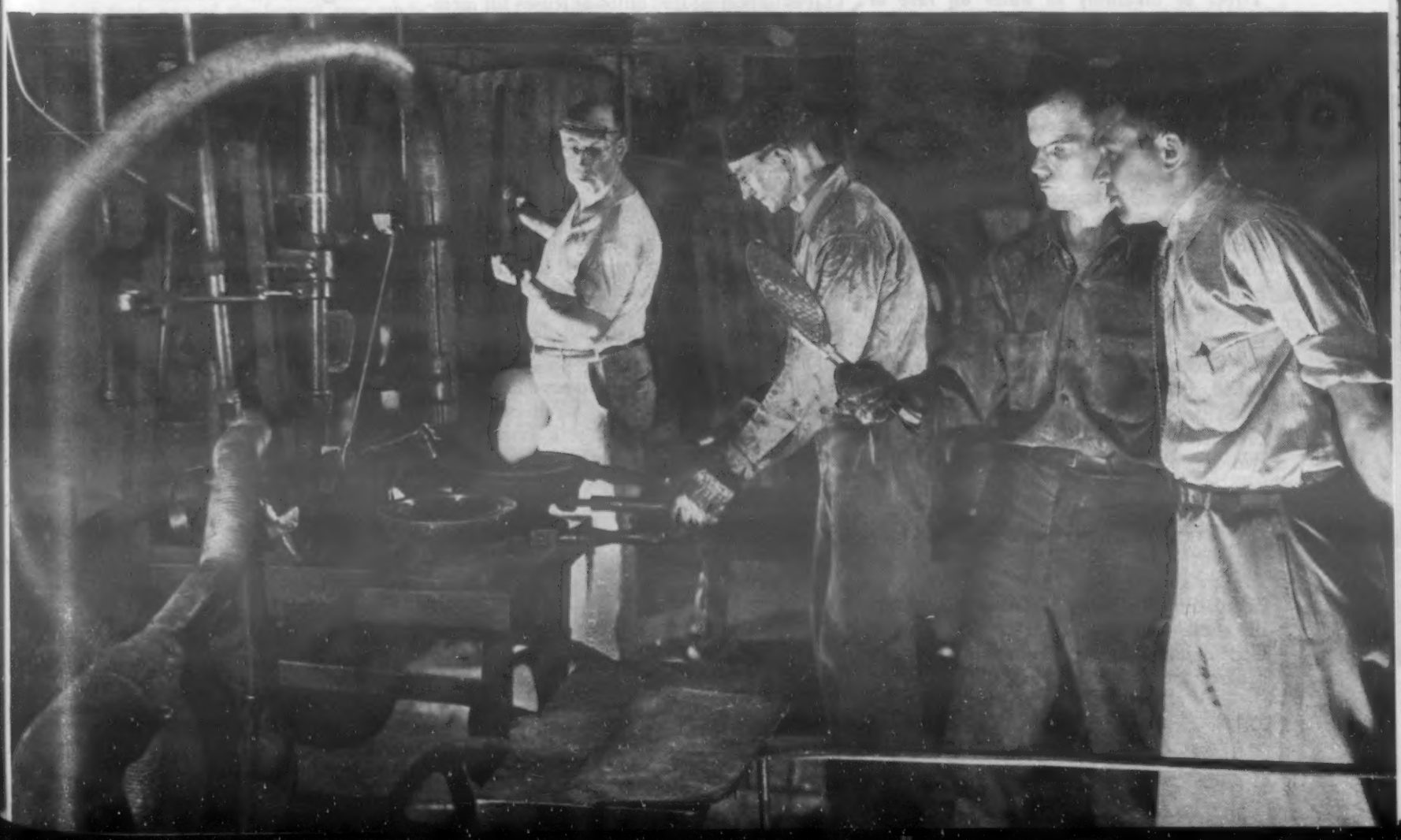
Thermal conductivity of the glasses at room temperature ranges from 0.0016 to 0.0029 cal/sec/deg C and most commercial glasses are near 0.0025 cal/sec/deg C. At temperatures of about 400 F conductivity is 20 to 25% higher.

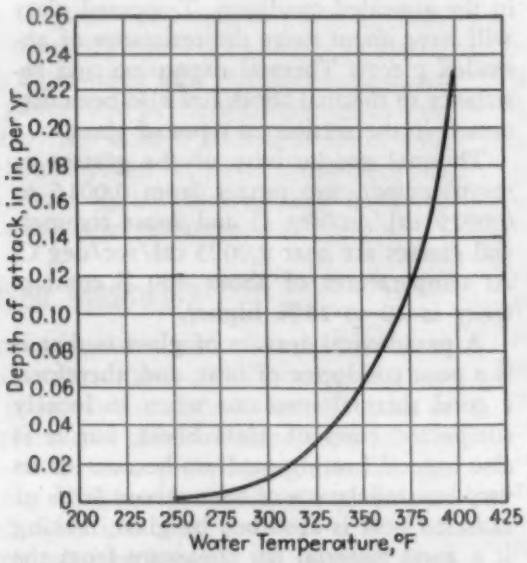
A paradoxical feature of glass is that it is a poor conductor of heat, and, therefore, a good thermal insulator when in loosely compacted batts of glass fibers, but it is also a good heating medium because of its very low reflectance of heat. About 90% of radiated heat is absorbed by glass, making it a good material for cookware from the standpoint of thermal efficiency.

Electrical Properties

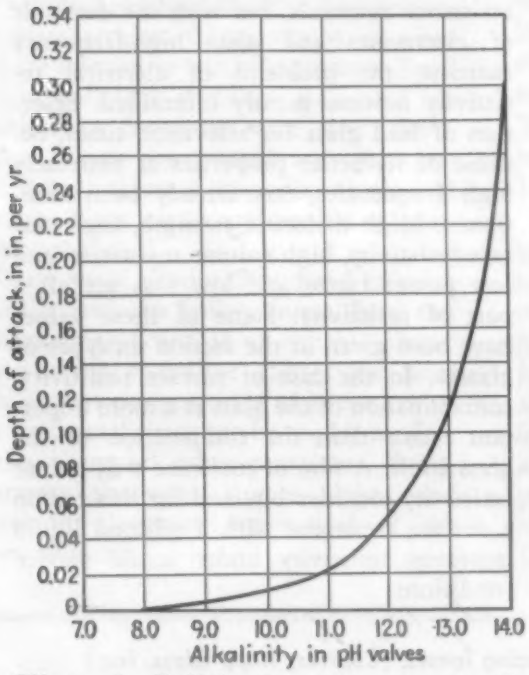
Glass is one of the standard electrical resistance materials, but with the demands of electronics and ultra high-frequency currents, the problems of electrical resistivity become greatly intensified. Selection of lead glass for television tubes, because of its better properties at extremely high frequencies, has already been mentioned. High dielectric strength, high surface resistivity, high volume resistivity, and low power factor and low loss are all a part of resistivity. Some of these values have been given in the section on types of glasses. In the case of surface resistivity, contamination of the glass is a more important factor than the composition of the glass itself. A film of moisture will reduce resistivity considerably, and for this reason a surface treatment with a silicone liquid improves resistivity under actual service conditions.

Glass products are fabricated by a variety of methods. Shown here is a method of producing lenses. (Courtesy Kopp Glass, Inc.)





Effect of water temperature on rate of attack upon a borosilicate glass.



Effect of alkalinity in water on rate of attack upon a borosilicate glass.

At the other extreme are the electrically conducting glasses. These are produced by several companies, in several different ways, but all consist of ordinary glass coated with a very thin film of a semiconductor, which passes current while permitting passage of light. The film can be applied in a range of resistances. While one type of film gives the glass a slight bluish tint, others are practically colorless. When the thickness of the film has been established, the resistance of the glass can be given per square area. This is because the conductor is, for all practical purposes, two-dimensional; therefore, for any square area, the relationship between the width of the path, decreasing resistance, and the length of the path, increasing resistance, is constant. The total ohmage in any conductive glass sheet, therefore, can be found by calculating the number of square areas in the sheet, and multiplying or dividing the unit ohmage according to whether the squares are arranged along the length or width of the path.

An important consideration of the assembling of electrically conductive glass into its mounting is proper use of connectors and insulators. Element temperatures can run as high as 650 F, so the insulators must be of a heat resistant type—porcelain or asbestos. Corner blocks and side blocks will provide successful insulation. Connection to the electric system must be made through a strip that will make good contact along the entire end widths of the sheet. Failure to do this will result in local hot spots where the current is concentrated. Permanently attached copper strips are best for connectors, but where the assembly requires it the connectors may be brass or nickel strips held against metallized strips along the edge of the glass by springs.

Dielectric constant is likewise important in the selection of a type of glass for an electrical or electronic application. Dielectric constants of several glasses, and of other important high-resistance materials, are:

Lead glass	2.2
Lime glass	7.0
Mica	7.3
Phenolic plastics	7.5
Porcelain	4.4–6.8
Hard rubber	2.8

Light Transmitting Properties

Light transmission is a variable property among the glasses. Common window glass, a lime glass, transmits about 85% to 95% of visible light, while the best optical glasses, lead glass, transmit about 99%.

It is possible to formulate glasses to cut off or to transmit almost any desired part of the visible spectrum, and of the regions both above and below it. Fortunately, these are the regions of greatest interest to industry. The infra-red bands of the electromagnetic spectrum are the heat radiations, and it is important that bulbs or lenses for infra-red lamps be made of a glass that will transmit a high percentage of these radiations. The ultra-violet frequencies, at the other end of the visible spectrum, are responsible for the destruction of micro-organisms, for the destruction of skin tissue in the phenomenon called sunburn, and for most of the fading in paints and dyes. Glasses to pass high percentages of ultra-violet light are used in germicidal and sun lamps, as already mentioned, and glasses to block off these radiations are used for various types of protective goggles, for glazing of store display windows, and for museum and similar display cases.

Of the bands further removed from the visible spectrum, it is the x-radiations that would be most important to industry. Here the glasses of very high lead content will block off most of the rays, and so give protection while permitting the visible rays to pass.

One of the most common of the special glasses is the heat-absorbing glass intended to shut out perhaps 90% of the heat rays while passing most of the visible spectrum. Glasses of this sort are widely used in glazing for railway cars, buses, aircraft control towers, etc. Most of these glasses contain small percentages of ferrous oxide, and have a faintly blue-green tinge. Contrariwise, glasses used for the bulbs of germicidal lamps must transmit as high a percentage as possible of ultra-violet light, as these are the radiations that destroy living organisms. Sun-tan lamps likewise achieve their effectiveness by passing a high percentage of ultra-violet radiation. The 96% silica glasses are useful here. Glasses for welder's goggles are intended to shut out all ultra-violet radiation and a large part of the visible spectrum as well, and these glasses are nearly opaque.

Other Properties

Fused quartz will have specific gravity of about 2.2; the borosilicate glasses will be a little heavier, about 2.23; lime glasses may be about 2.5; while lead glasses will be still heavier, depending upon the percentage of lead in the formulation.

Resistance to chemical attack is one of the outstanding attributes of glass, as has been mentioned. Hydrofluoric acid, hot concentrated phosphoric acid and strong alkalies attack glass, the last-named slowly at room temperature, but rapidly at elevated temperatures. Water has a slight solvent action upon glass at ordinary temperatures, varying from negligible attack upon the borosilicate and high-silica glasses to perceptible attack upon the lime glasses. Water at temperatures above 300 F, as in boilers, attacks glass, slowly at 300 F, with increasing rapidity as the temperature rises. Slight alkalinity of the water also speeds attack. Borosilicate or other high-silica glass should be chosen for service involving water at temperatures above 300 F. Although these glasses are attacked, the rate is not so great as to prevent a satisfactory service life.

Design Considerations

Any design using glass, either as a principal member or as part of an assembly, might well be submitted to the manufacturer of the glass components for suggestions. It is possible to increase the effectiveness of glass as a component, and sometimes to decrease the cost of the item, by designing to avoid points such as loading in tension, unnecessary thermal stresses, and notches that serve as stress-raisers, or to obtain benefit of most economical fabricating methods. While each design must be studied individually, a few guides can be outlined for general use.

As glass always breaks in tension, and shows no cold flow, it is highly notch-sensitive. Designs should avoid sharp re-entrant angles as much as possible, and radii on molded pieces should be ample, both for strength and for ease in fabricating. Pieces of irregular outline or certain types of irregular section are unsatisfactory for heat-strengthening also. Glass, with almost perfect elasticity, practically no creep, and no cold flow in the engineering sense, shows no dynamic fatigue, but does show static fatigue in moderate degree. In addition, glass, a noncrystalline material, is

subject to viscous flow, inconsequential at room temperature, but appreciable at elevated temperatures. The service temperatures listed with the composition types of glasses give an indication of this (see tables).

Some ideas as to the limitations of the forming methods of glass will be given with the outline of those methods, in the next section. For blown ware, the lowest cost method for large quantities is press and blow fabrication. For all blown ware, the first bubble, or blank, will be roughly pear-shaped, and the distribution of glass in the finished piece should correspond to that in this shape. Long, thin necks, sharp changes in contour, and pieces having wider or heavier sections near the top are difficult to form by blowing. Wall thicknesses can be lighter in blown ware than in pressed ware.

Pressed ware requires sections thick enough so that the glass will retain sufficient fluidity to fill the mold. Drafts and corner radii should be large enough to permit easy molding and withdrawal of the molded piece. Wide flanges, sharp recesses and thin ridges should be avoided if possible. Block molding is the simplest and lowest in cost of the methods for pressing glass, and should be chosen whenever possible. By relocating lettering or other projections on the bottom instead of the sides of the piece, the design may sometimes be adapted to block molding from some more complicated method.

Sealing, whether by fusion or mechanical means, involves few problems that have not already been mentioned. As glass has a much lower coefficient of expansion than most metals, metallic lead wires through glass require special attention. In the first electric lamps, short pieces of platinum wire were used to carry the leads through the glass envelope, but a copper alloy was soon developed that had a coefficient of expansion very similar to that of glass. Other copper alloys are now available for bonding to glass.

Even sprayed metal can be bonded to glass firmly enough to permit attachment to metal by soldering. When coatings of silver or gold are fired on the glass at high temperatures, the bond is strong enough to hold a vacuum. Low-melting solders are used for attaching metallic members, and the indium solders are especially useful for high-quality work.

Engineers are beginning to take advantage of the possibilities presented by glass laminating. Whereas this process once meant the bonding together of two sheets or plates of clear and colorless glass with a plastics elastomer, the process is now being extended to the bonding of heat-strengthened plate or sheet into extremely strong transparent materials. These have widened the uses of glass. Crane cabs intended for outdoor use have been enclosed with laminated glass of a heat-absorbing type to reduce the amount of solar heat the crane operator must endure in summer. Another composite of an even more unusual nature was the production of glass enclosures for animal cages in zoos, the glass a laminate of heat-strengthened plate, and with the inner surface coated so as to make it electrically conductive, to discourage soiling by the animals.

The advantages of the interlayer are now beginning to appear. By tinting the plastics material in a gradation of shades of blue-green from dark to colorless, a new type of nonglare windshield has been made for the automotive industry. The windshield, which reduces glare from the sky while leaving the view of the road unimpaired, would have been difficult to prepare by tinting the glass.

Another recent development has been that of thin strips of lead glass of very high resistivity to high frequency electric current. These have been used as dielectrics in small condensers, replacing mica for this purpose. Design characteristics of the glass are quite close to those of the mica.

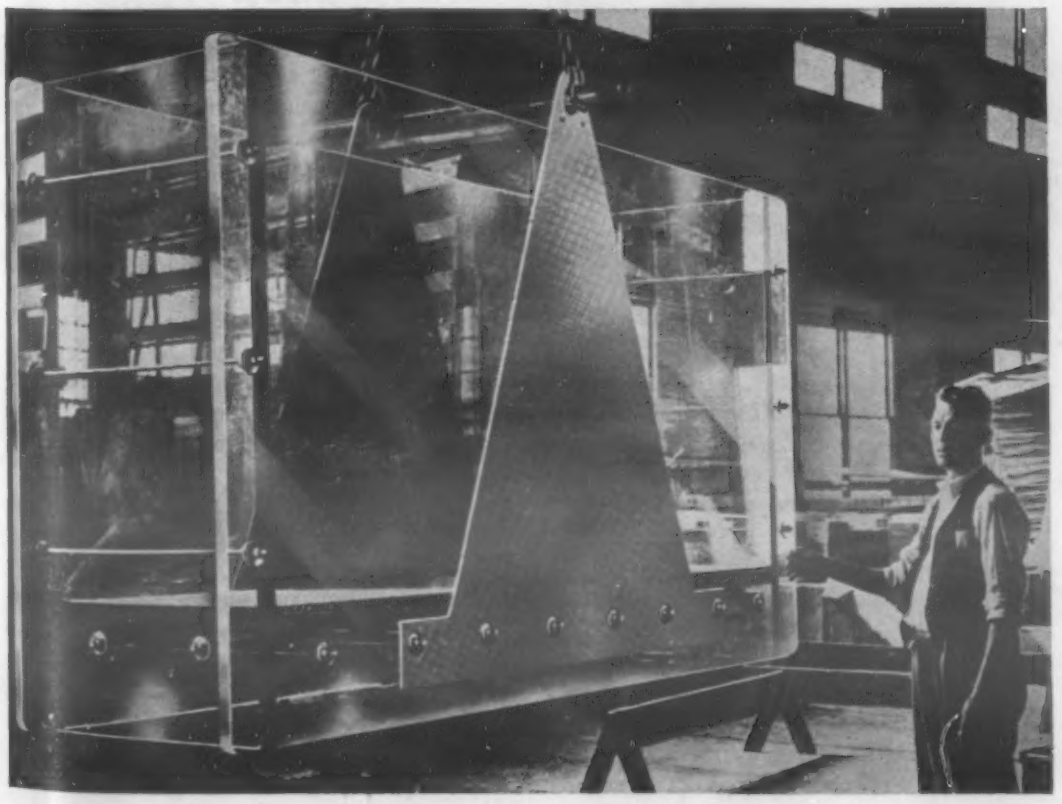
Fabricating Glass

Glass is usually produced to finished form by the manufacturer of the material. One of the few notable exceptions is sheet glass, which is easily cut to simple size and shape specifications by the user. Even here the trend is toward the use of special glazing for vehicles, and much of such glazing, whether laminated safety glass, double glass, or other specialty, is finished to size by the glass manufacturer. Rod and tube are also frequently cut to size or bent to simple shapes by the users.

Glass can be ground and polished without great difficulty, but any machining other than drilling or sawing is impractical. Sawing can be done easily with an impregnated wheel, usually using diamond powder. Drilling is accomplished with difficulty, using special carbide-tipped drills, and kerosene as a lubricant.

This limited workability, and the fact that the hot-forming of glass is so specialized a procedure that the user ordinarily has neither the equipment nor the skill among his own personnel to do such work, has left the forming of glass with the manufacturer.

This glass tank, one of the largest ever made, was used for special war work during World War II. (Courtesy Pittsburgh Plate Glass Co.)



Melting

The ingredients for glassmaking, such as sand of special grade, soda ash, limestone of high purity, feldspar, borax, etc., are melted together for many hours so that the materials are reduced to oxides, the mixture can become homogeneous, and "fine," *i.e.*, gas bubbles and undissolved stones, leave the main body of the molten material. The melting can be accomplished at a temperature between about 2400 and 2900 F, and the heating will be continued for several hours after the mixture has become a thick liquid to permit proper fining.

Melting can be done in a pot, consisting of a refractory crucible, usually rectangular

in form, cemented into a pot furnace; in a day tank, which is a small separately fired furnace; or in a continuous tank, which is a large hearth-type furnace arranged for continuous melting. The pots are the low-capacity melting units of the industry; they are used for producing limited quantities of special glasses, or small batches of standard compositions. The ingredients are charged into the pot, the pot is heated for about 24 hr to melt the charge and permit it to become "fine," and the glass is then worked out until all the good glass has been used. A number of pots are arranged around the periphery of a pot furnace, so that a single furnace can be used to produce many small batches by this method.

Day tanks have larger capacity than the pots in the pot furnace, and are used where quantity requirements are higher than could be satisfied with the pot furnace, but not high enough to justify use of the continuous furnace. Operation of the day tank is the same as for pot melting, with the materials charged into the tank, melted, and worked away, after which the furnace is recharged.

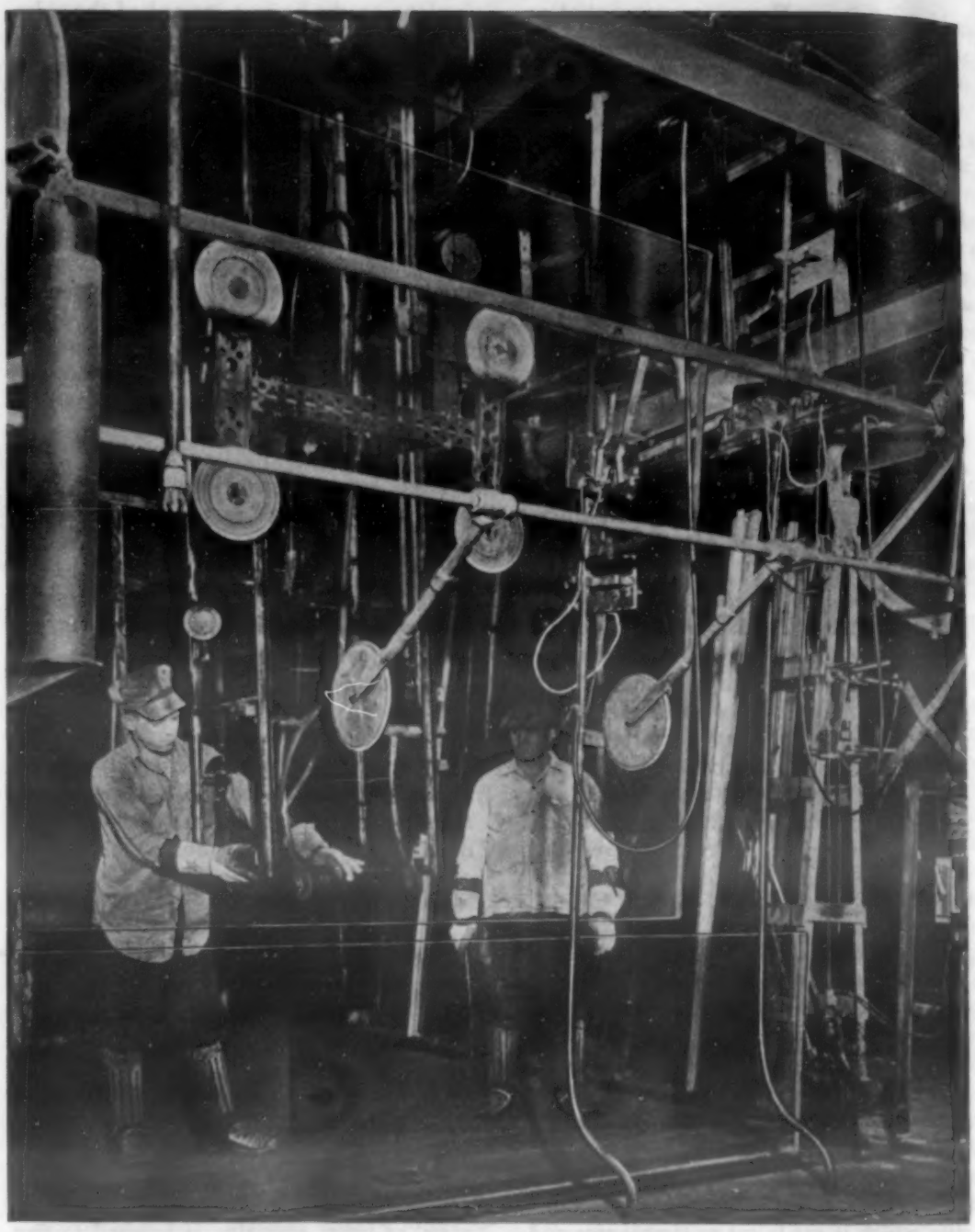
With the continuous tank batch, melting gives way to continuous melting, and the materials are charged at one end of a tank, melted, worked into the fining end of the tank, and there removed for processing. Sheet glass is extruded continuously through a small slit that feeds a wide ribbon of glass vertically downward through guides as it cools.

Glass is formed by blowing, pressing, drawing, rolling, multiforming, and by special processes for sheeting, as just described. There are many variations of the processes. Several of these produce glass in sheets, rod or tube form, the only forms in which it is supplied to industry for additional fabrication to any extent.

Semifabrication

Drawing is done by any of several special machines to produce glass tubing or rod. One of the most common of the drawing machines illustrates the procedure. Here tubing is drawn down from a hollow round, the round itself being formed by pouring molten glass in a thin stream onto a revolving mandrel. As the refractory mandrel turns, the stream of molten glass is consolidated into a coating over it, and this coating slides off the end of the inclined mandrel as a continuous tube of large size. This is drawn down to smaller diameter as it moves away from the mandrel. A stream of air blown through the newly formed tube prevents it from collapsing, and speeds cooling, while a series of rolls guide and support the tube. At the end of the line of supporting rolls the tubing has hardened, and it is automatically cut to stock lengths.

Tubing is produced in standard diameters ranging from $\frac{1}{8}$ to 6 in., or slightly larger. Lengths range from 48 to 60 in., with special lengths cut to order up to about 144 in. Rod is made in standard diameters of from $\frac{1}{4}$ to 1 in. Ends are cut, fire polished or ground, depending upon the use to which it is to be put.



Sheet glass is cut into uniform sizes by an electrically charged mechanism.
(Courtesy Pittsburgh Plate Glass Co.)

Another glass product made by drawing is the filament that its matted, woven, or otherwise processed into glass wool, fabric, cord or mat. The filaments are made by melting down a batch of small glass balls, exuding the molten glass from tiny orifices much as other synthetic filaments are exuded, and drawing out the filament on a blast of air. The size of the filament can be regulated by the velocity of the blast of air, in connection with the conditions of melting. The filaments can be spun into a fiber, and the fiber afterwards woven into fabric, braided into cord, or matted into a sheet. The fine filament can be built up into woolly masses, called batts, and used as such, or the batts can be compacted with a binder and under pressure to form blocks or boards.

Rolling is a process for producing glass sheet with a surface figure. The hot glass is rolled to the required thickness between rolls, the surfaces of which contain the design to be rolled into the softened glass. Knurled markings in a variety of patterns are formed on the surface of the glass sheet.

Rolled sheet is produced in standard thicknesses of from $\frac{3}{16}$ to $1\frac{1}{4}$ in. Its greatest use is in the production of plate glass, for which the knurled pattern assists in the grinding and polishing.

Sheet extrusion, the high-production method for making sheet glass, is a continuous process that utilizes the continuous tank for melting. From the fining end of this tank a wide ribbon of glass exudes through a narrow slit that extends along the end of the tank near the bottom. The viscous glass flows vertically downward, with guide rollers along both sides, and is cooled as it descends. After travelling about 20 ft or more, the sheet has hardened and, still in a vertical position, it is cut off to the desired length.

The sheet is usually fire polished to give it a uniformly glossy surface, and another heat treatment will relieve locked-up stresses. The continuous production of sheet glass has lowered the cost of this type of glass, and considerably improved the quality.

Blowing

Glassblowing had its origin several thou-

sand years ago, and has evolved into a number of high-production processes that have been mechanized, and are largely automatic or semi-automatic, but it is still the technique popularly thought of as peculiar to glassmaking. In spite of modernization, the original process continues with the original equipment in the operation known as offhand blowing.

Offhand blowing is accomplished by the glassblower with only the blowpipe and a few simple hand tools, such as carbon blocks, rods and shears. The glassblower picks up a blob of molten glass from the pot or furnace with the blowpipe (the "gather") and shapes it by blowing through the pipe as the glass cools. The shape is partially controlled by flattening against the carbon block, or indenting with the carbon rods, or by other means, but the success of the work is dependent upon the skill of the glassblower.

This blowing with assistance of only the simplest of hand tools developed into mold blowing, in which the glassblower was assisted in shaping the material by blowing the glass inside a mold. Mold blowing was later mechanized to produce the present-day molding machines. At present the blowpipe is used for production of many kinds of hollow ware, both with and without the assistance of a mold. Short runs, sample pieces, and other small lot jobs in which it would be impossible to recover the cost of molds or machinery, art ware, experimental pieces, laboratory glassware, etc., are made by offhand blowing.

Paste mold blowing, done by hand or by machine, is a rapid, low-cost production method for pieces that are circular in section and so can be rotated in the mold. It is limited to small- and medium-sized pieces. When done by hand or by machine, the glass is gathered on the blow iron, a bubble is blown, and the bubble is placed inside a mold, usually of cast iron, the walls of which are coated with a carbonaceous slurry, or paste. The bubble is then blown out to the walls of the mold and is rotated from the blow iron. The steam formed from the slurry acts as a cushion, and the piece is given a good gloss by the rotating motion in the mold.

When an article to be made of glass by blowing is circular in section, is not too large to be spun in a mold, and is required to have a fine surface finish, paste mold blowing is the method to be used. Typical of the pieces made by this method are incandescent lamp bulbs, coffee makers, laboratory flasks, and tumblers.

When paste mold blowing is done by hand, the smallest desirable run for small pieces is about 1,000; for medium-sized pieces, about 350; and for large pieces, about 50. Machine operation will require a minimum run of about 100,000 pieces of small size, or about 75,000 if the pieces are medium-sized or large. Pieces up to 30 in. in height have been successfully hand-blown in production runs, and work up to 10 in. high has been machine-made. Pieces to 35 lb. have been hand-blown, while 1 lb. is about the limit for machine blowing.

Hot iron mold blowing makes use of cast iron molds without the coating of carbonaceous slurry over the inside surfaces. It is primarily for hand-blowing operations. The work is not rotated in the mold, and so the surface of the molded piece is not as glossy as that made in paste molds, but the method is suitable for molding pieces having noncircular sections, or raised lettering, or other projections that would prevent rotation. It is also used for hand-blowing pieces that are too large for machine production. When quantities of a given article are not large enough to warrant the machine set-up for press-and-blow work, hot iron blowing is the logical selection for a production method.

As the glass is blown directly against the iron walls of the mold, the finish is not as fine as with paste mold blowing. In both paste mold blowing and hot iron mold blowing the piece is still attached to the blow iron at the end of the blowing, and must be broken loose in the operation, known as "cracking off." A trimming operation completes removal of the surplus glass from the location at which the blow iron was attached. This operation is called "neck trimming." If the design provides for a circular section at the point of trim, the trimming can be done by a flame, which is the lowest-cost method.

For small pieces, the least number of pieces that can be economically run by hot iron mold blowing is about 2,000; for medium pieces, about 700, and for large

Fiberglas is widely used in industry and in construction work as an insulating material. ***(Courtesy Owens-Corning Fiberglas Corp.)***

pieces, about 50. Pieces up to about 30 in. high and 10 in. in dia., weighing about 35 lb, have been produced by this means on production runs.

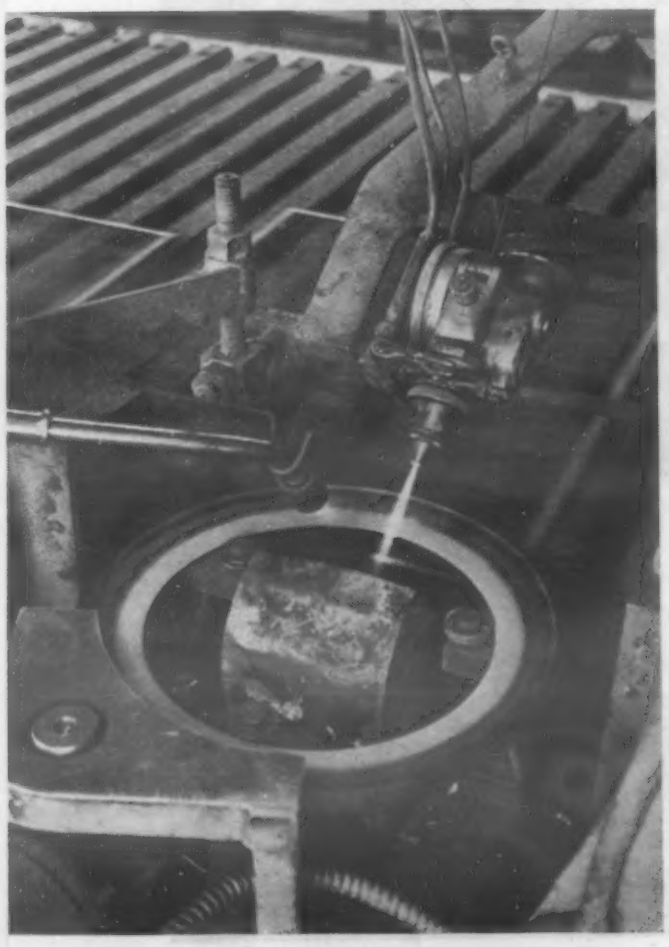
Press and blow blowing is a machine process, and is the standard high-production method for parts not too large to be made by machine, and not requiring the high finish of paste mold ware. It is usually the lowest-cost production method for blown ware in quantity.

The press and blow process is a two-step operation that produces parts of circular or noncircular sections, with or without projections, raised lettering, etc. In the first step the gob of molten glass is put into a press mold, and a plunger forms a cup and squeezes the glass into a first step neck form. The piece is then attached to a blowing head, is removed from the press mold, and transferred to a blow mold, and blown out to fill the mold cavity. As the neck of the piece is partially formed in the press mold, and blowing is done through a blowing head rather than with a blow iron, the neck is finished in the machine and a trimming operation is not required.

Because of its low cost, and the fact that pieces with raised letters or with threaded necks can be made by press and blow blowing, the process is standard for the making of bottles, jars, and similar items in the container field. Graduated flasks, humidifier floats, and other high-production items are typical of press and blow ware.

Machine processing means that long runs are necessary to get out the cost of tooling. The smallest desirable run with small pieces is about 150,000; with medium-sized pieces it is about 100,000; and large pieces can be made in quantities as small as 50,000. Pieces to 12 in. in height, and to about 3½ lb in weight, have been successfully made by press and blow blowing.

In the manufacture of double glass, the edges of the two layers of glass are metallized, as shown here, in order to make a bond between separator strip and surface of glass. (Courtesy Libbey-Owens-Ford Glass Co.)



Pressing

When the form of the piece to be made precludes blowing, pressing of the glass in a mold can be considered. Pressing of glass resembles the molding of thermosetting resins in that the gob of glass is put into the mold and then squeezed to fill the mold cavity by a plunger. Unlike compression molding of plastics, no chemical reaction occurs to harden the piece, and it sets by simple cooling.

Pressing is not confined to hollow ware, though the plunger can serve as a core when a hollow piece is to be made. Solid pieces can be made by pressing the gob of glass from a small reservoir in the mold into the mold cavity itself. It is necessary, however, that molded pieces be of such form that they can be withdrawn from the mold. Adequate draft must be provided on the sides, and sections must be thick enough to permit flow of the molten glass without excessive chilling. Operations can be performed by hand or mechanically, with hand work ordinarily filling in when the sizes of the pieces to be made are beyond the capacity of the machines. There are three types of mold pressing, differentiated according to the type of mold used—block mold, split mold and font mold.

Block mold pressing makes use of a solid mold, with a movable ring at the top to seal the mold cavity. The plunger operates through this ring. A gob of hot glass is put into the mold, the ring and plunger seal the mold, and the plunger forces the glass throughout the cavity. A few seconds later the glass has set, the plunger is retracted, and the glass piece is removed from the mold.

Since there is no provision for overflow of the glass, the plunger continues to squeeze the glass into all parts of the mold cavity until the cavity is filled, and then must stop. Weight of the pieces and thickness of the bottoms will accordingly vary somewhat from piece to piece.

As the block mold is a solid mold, the only seam showing in the finished piece is the slight horizontal parting line where the sealing ring rests against the body of the mold. This is called the ring line.

Block mold ware, when hand produced, can be successfully made in sizes up to about 24 in. maximum dimension, and weighing to 20 lb. Machine-made ware can weigh up to 10 lb, with 18 in. the maximum dimension. The smallest number of pieces for an economical production run in small hand-produced pieces is about 1200; in medium-sized pieces, about 800; and in large pieces, about 500; with machine-made ware, the smallest economical production run is about 50,000 pieces of small size, about 35,000 of medium size, or about 25,000 of large size.

Draft on the sides of the mold cavity should be about 2 to 4 deg for the outside surfaces of the piece, and about 3 to 5 deg for inside surfaces, with the smaller draft angles on the shorter heights. Baking dishes, ash trays and headlight lenses are examples of block mold pressed ware.

Split mold pressing is used when the shape of the piece is such that it could not be withdrawn from a solid mold. The mold can be hinged at one place, or at several, but hinging at only one place is greatly to be desired because it minimizes mold upkeep and mismatch. Costs are usually higher for split mold pressing than for block mold ware.

The actual pressing process is like that for block mold work. The piece shows a horizontal seam at each split in the mold. As with block mold pressing, there is no provision for overflow of excess glass, and the weight of pieces may vary with variation in quantity of glass placed in the mold.

Split mold pressing is indicated when a piece to be molded is of hollow or dished form, but includes projections, lettering, lens prisms, or other irregularities that would prevent its being withdrawn from a solid mold. Fresnel lenses, insulators, and the like are examples of split mold ware.

Split mold pressed ware can be made by hand or by machine. Hand ware can be as large as 24 in. maximum dimension, and weigh as much as 20 lb, while machine ware will usually be smaller than 18 in. maximum dimension, and weigh less than 10 lb per piece. The least number of pieces in an economical production run, using hand methods, is about 1200 if the pieces are small, about 800 if of medium size, or about 500 if large. If machine methods were being used, the smallest number of pieces to permit recovery of setup costs is about 50,000 small pieces, about 35,000 medium-sized pieces, or about 25,000 large pieces.

Font mold pressing, chosen especially when the part to be produced is solid or nearly so, provides for a small chamber into which the gob of glass is loaded. For high production the mold can have a number of cavities fed from a central cup. The plunger is applied to this cup or chamber, forcing the molten glass into the mold cavity or cavities. As the molten glass will fill the cavity exactly, and the surplus will remain in the cup, the pressed glass pieces are not subject to the weight variation that affects other types of pressings. The pressed pieces are later broken away from the residue from the cup and gate.

While hollow pieces cannot be made by this method, the piece can contain holes if the mating core pieces can be incorporated into the mold. A trimming operation is required to finish the piece.

Font mold pressing is both machine produced and hand fabricated. Pieces can be as large as 2½ in. wide, or to 12 in. long, and can weigh as much as 5 lb. For hand production the smallest desirable quantity for a production run is about 1200 small pieces, or about 800 medium-sized pieces, or about 500 large pieces. For machine production the smallest desirable number of pieces is about 50,000 small pieces, 35,000 medium-sized pieces, or about 25,000 large pieces.

Cast iron molds used in production of glass products are carefully finished by hand. (Courtesy Owens-Illinois Glass Co.)

Multiforming

Multiforming, another process for forming glass pieces, parallels the operations of powder metallurgy in both procedure and results. Glass is ground into a fine powder, and this powder is either dry pressed into the desired shape as a first operation, or is suspended in water and the resulting slip is slip cast to shape. The formed pieces are then fired to fuse the glass particles into solid or semiporous homogenous parts.

This method of reforming glass has made practicable the fabrication of pieces outside the scope of other forming methods. The slip casting technique makes it possible to produce pieces of a size, and with heavier sections, than could be produced in quantity by hot molding methods. Pieces to 50 lb in weight have been produced, and sections as thin as 1/8 in. or as thick as 1½ in. have been made.

The ware is white and opaque. Large slabs of glass, large cylinders and crucibles, bubble caps and perforated plates are typical of the bigger pieces, while small sealing beads for glass-to-metal seals illustrate the smaller parts. These small pieces, sometimes only 0.1 in. in dia, are usually made by powder molding.

Secondary Operations

In fabrication of glass there are several secondary operations, one or more of which can be performed upon the glass after it has been formed from the molten material. Stress relieving, heat strengthening, drilling, cutting, heat sealing, mechanical sealing and metallizing are the most important of these. In contrast to the forming processes already considered, it is possible for these secondary operations to be performed by the manufacturer using the glass part.

Stress relieving, usually called annealing, consists of heating the glass to a temperature that will relieve the stresses, and then cooling slowly to avoid restressing. Stresses result from uneven cooling, with consequent uneven contraction, after heating or hot-forming.

Stress relief temperatures for some of the common types of glass are as follows:

	Temp, F
Soda lime, general purpose	940
Hard lime, heat resistant	1315
Lead, lamp tubing	800
Lead, easy working	860
Lead, electrical	800
Borosilicate, general purpose	1030
Borosilicate, electrical	950
Borosilicate, heat resistant	1065
96% silica, high temperature	1670
96% silica, ultraviolet transmit.	1670

Heat-strengthening of glass is usually done by the glass manufacturer, as it requires careful control of temperature. It is also known as tempering, or by various trade names. It consists of heating the glass to about 1150 F, for most common types, then chilling by means of a blast of cool air, or by some other method. The air cools the surface layers of the glass, causing them to contract somewhat. As the body of the glass cools, the surface layers are compressed by the shrinkage of the whole mass of the article. The result of this treatment is to develop compressive stresses in the surface layers of the glass, while the inner portion is in tension.

Glass is about 10 times as strong in compression as in tension, so the treatment has the effect of strengthening the glass against breakage by bending, whether under steady pressure or as a result of a blow. The strengthened glass remains notch-sensitive, however, and can be broken at relatively low load if first scratched or notched at the surface.

Borosilicate glasses can be heat-strengthened also, by heating to about 1300 F and chilling, but the strength increase is not as marked as with the glasses having greater coefficients of thermal expansion. The higher-silica glasses have coefficients so low that the necessary stress gradient cannot be established, and heat-strengthening cannot be accomplished.

Not all shapes can be economically heat-strengthened. Where the shape of the piece is such that the preliminary surface shrinkage leads to stress concentrations, the strengthening process will be unsuccessful. Also, the high-silica glasses, such as the 96% silica types and fused quartz, cannot be successfully heat-strengthened, as their shrinkage is too small to set up the necessary stress pattern.

Heat-strengthening will increase the strength of a piece of glass by two to four times. As the glass remains notch-sensitive, it must be cut to shape, all holes drilled, and similar work finished before the strengthening process is performed.

Drilling is one of the few machining operations that can be performed upon glass. The drilling action resembles drilling of rock more closely than the drilling of metals. By using a carbide-tipped drill of special type, intended for use with glass, and with kerosene as a lubricant, holes can be drilled accurately in glass at a reasonable rate of speed.

As a substitute for drilling, it is frequently possible to mold hollow bosses into glassware, and to grind them off to form the hole. Molding of holes directly is more difficult in glassware than in most other materials, except where mating core pins, meeting inside the location of the hole and withdrawn from both ends, are used.

Cutting can be done by scoring with a diamond or other hard-pointed scriber, and breaking the glass along the scratch, or by sawing with an abrasive wheel or with a charged lap. This is the most common fabricating method used with glass in industry. Sheet glass can be cut without difficulty with a hard scriber, the scriber making only a small scratch in the surface of the glass along the line where the break is to occur. Rods and tubes can be cut in bundles with a thin abrasive wheel, or with a diamond saw.

Hot sealing corresponds to fusion welding of metals or plastics, and is widely used for fabrication of elaborate piping systems, for building up assemblies of molded or handmade pieces into a single piece. Heat sealing makes it possible to join machine-made pieces to each other, or to handmade parts, in the formation of a glass article that could not be economically made as a unit. In the manufacture of a television tube, for example, the simple form will be made by joining three pieces—a bulb blown or pressed to form the body of the tube, joined to a face pressed to accurate inner surface, and to a tube forming the neck.

Heat sealing can be done by an open flame, using a blast lamp or gas torch, or by electric heating, using special equipment. It is necessary that the units joined have coefficients of expansion closely similar, or else that one or more intermediate pieces, of intermediate coefficient, be used between the units, so that there is a graduation of expansion. The same procedure may be necessary when joining metal to glass if the parts are of such size and shape, and the assembly will be exposed to such temperature variation, as will make careful adjustment necessary.

Mechanical sealing is an alternate assembly method, and is used especially for the joining of glass to other materials. It has the additional advantage of being separable in most cases. Assembly is usually accomplished by clamping. Several considerations regarding clamping are:

1. The unit should be designed so that clamping forces upon the glass are predominantly compressive. Bending, tension and shear should be avoided, or minimized as much as possible.

2. When clamping glass to metal, resilient pads should be placed between the surfaces to avoid stress concentrations.

3. Metal clamping parts should be designed for even application of force. Clamping bolts or screws should be of such size and number, and the clamping ring, if any, should be sufficiently rigid, so that localized stresses will not be built up. Bolt holes or bolt notches should not be located in the glass flanges.

In addition to clamping, glass-to-metal assemblies are sometimes made by pouring a low-melting metal, such as lead, bismuth bearing compounds, and solders, around a part of the glass unit and fastening other metal parts to the low-melting metal by any applicable method. The metal-to-glass seal in this case is a mechanical joint, held by friction only, and without any actual fusion bonding. Sealing of this sort is not separable.

Metallizing, consisting of producing an intimate bond between glass and metal, can be used as the basis for firm joining of metal and glass units, or may effect desired results by itself. For example, after glass windows over instruments are metallized around the edges, the glass can be soldered into metal covers just as metal would be soldered to metal; silver bands deposited upon glass coil forms become a path for an electric current in an inductance coil.

Metallizing can be done by several methods:

1. Spraying, painting. Vaporized metal from a metal spray gun can be deposited upon glass, and brass and aluminum are much used for this purpose. Silver paste has been applied to glass by the silk screen process, by roller coating, and by painting with a brush over a stencil to form electrical conductors or capacitor surfaces.

2. Chemical deposition. The mirror reaction has been used for more than a century to lay down a film of silver or other metal on glass. The most common metals used are the noble metals, silver, gold, platinum, osmium and rhodium.

3. Special techniques. Certain of the metallizing techniques extensively used by the vacuum tube makers involve the firing of the metal film onto the glass. A very firm bond results. With this, as with films applied by other methods, it is frequently necessary to build up the thin layer of metal actually bonded to the glass, and this can be done by plating with copper or tin. Metal components can then be soldered to the bonded metal just as for any metal-to-metal soldering, with proper precautions against damaging the glass. Solders used are usually the "50-50" tin-lead solder, silver-lead solders of low melting point, or bismuth solders.

Several precautions should be taken in designing glass-metal assemblies with metallized glass. These are (a) permit flexing of the metal part to take up differential expansion, by using light gage metal; (b) rings, diaphragms and caps should be designed so that stresses in the glass will be compressive; and (c) stresses should be kept as near the plane normal to the glass surface as possible, or they should be minimized by keeping the area of glass to metal contact as small as possible, with the soldered metal at least ⅛ in. within the metallized area.

Acknowledgments

The personnel or publications of the following companies have been consulted in the preparation of this manual:

Corning Glass Works
Kopp Glass, Inc.
Libby-Owens-Ford Glass Co.
Mississippi Glass Co.
Owens-Corning Fiberglas Corp.
Owens-Illinois Glass Co.
Pittsburgh Plate Glass Co.

Materials Engineering File Facts

NUMBER 205
March, 1951

Nickel-Chromium-Molybdenum Steels

MATERIALS DATA SHEET

This data sheet covers representative grades of the 8600 and 8700 series of steels. Although the 8600 and 8700 series are similar in composition (except for molybdenum) and properties, the 8700 steels are somewhat deeper hardening and their properties are maintained to heavier section sizes.

Typical Properties

AISI TYPE	8620 8720	8630	8640 8740	8650 8750
COMPOSITION, %	C, 0.18-0.23 Mn, 0.70-0.90 Ni, 0.40-0.70 Cr, 0.40-0.60 Mo 0.15-0.25 0.20-0.30	C, 0.28-0.33 Mn, 0.70-0.90 Ni, 0.40-0.70 Cr, 0.40-0.60 Mo 0.15-0.25	C, 0.38-0.43 Mn, 0.75-1.00 Ni, 0.40-0.70 Cr, 0.40-0.60 Mo 0.15-0.25 0.20-0.30	C, 0.48-0.53 Mn, 0.75-1.00 Ni, 0.40-0.70 Cr, 0.40-0.60 Mo 0.15-0.25 0.20-0.30
PHYSICAL PROPERTIES				
Density, Lb/Cu In.	0.283	0.283	0.283	0.283
Melting Point (Approx) F	2755	2750	2745	2745
Thermal Cond (Approx), Btu/Hr/Sq Ft/In./Deg F, @ 120 F	260	260	260	260
Coeff of Exp per Deg F:				
0 to 200 F	6.45×10^{-6}	6.45×10^{-6}	6.45×10^{-6}	6.45×10^{-6}
0 to 1200 F	8.25×10^{-6}	8.25×10^{-6}	8.25×10^{-6}	8.25×10^{-6}
Spec Ht, (Approx), Btu/Lb/Deg F:	0.107	0.107	0.107	0.107
Elect Res (Approx), Microhm-Cm:				
at 120 F	30	30	30	30
at 570 F	48	48	48	48
Magnetic Properties	Magnetic	Magnetic	Magnetic	Magnetic
MECHANICAL PROPERTIES				
Mod of Elast in Tension, Psi	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$	$29\text{-}30 \times 10^6$
Tensile Str, 1000 Psi:				
Normalized	94.0	112.0	130.0	149.0
As Rolled	91.0	109.0	126.0	143.0
Annealed	77.0	86.0	95.0	105.0
Hard. & Temp @ 800 F[1]	122.0	162.0	208.0	214.0
Hard. & Temp @ 1200 F[1]	96.0	111.0	130.0	136.0
Yield Str, 1000 Psi:				
Normalized	61.0	73.0	85.0	96.0
As Rolled	65.0	78.0	90.0	101.0
Annealed	51.0	58.0	63.0	70.0
Hard. & Temp @ 800 F[1]	98.0	142.0	183.0	194.0
Hard. & Temp @ 1200 F[1]	76.0	92.0	110.0	116.0
Elong in 2 In., %:				
Normalized	29	23	18	11
As Rolled	29	25	20	17
Annealed	32	29	27	23
Hard. & Temp @ 800 F[1]	21	14	13	12
Hard. & Temp @ 1200 F[1]	26	23	21	21
Reduction of Area, %:				
Normalized	61	52	45	36
As Rolled	56	48	40	31
Annealed	64	59	55	50
Hard. & Temp @ 800 F[1]	63	54	43	41
Hard. & Temp @ 1200 F[1]	70	66	60	61
Hardness, Bhn:				
Normalized	190	225	262	300
As Rolled	185	220	244	290
Annealed	163	174	193	210
Hard. & Temp @ 800 F[1]	245	325	420	423
Hard. & Temp @ 1200 F[1]	193	225	262	271
Impact Str, Izod, Ft-Lb:				
Hard. & Temp @ 800 F[1]	76	42	18	—
Hard. & Temp @ 1200 F[1]	105	91	68	—
FABRICATING PROPERTIES				
Annealing Temp, F	1550-1600	1550-1600	1550-1600	1550-1600
Hardening Temp, F	1525-1575	1525-1575	1500-1550	1475-1550
Max Hot Working Temp (Approx), F	2200	2200	2200	2150
Machinability Index[2] (AISI B1112=100)	57	61	55	45
Weldability:	Readily weldable by oxyacetylene, inert arc and electrical resistance methods. Preheating is desirable for grades with more than 0.30 carbon content.			
CORROSION RESISTANCE	Have better corrosion resistance than the plain carbon steels.			
AVAILABLE FORMS	Usually supplied as bars, forgings, tubing, billets and sometimes in other steel mill forms.			
USES	Medium-duty carburized parts such as gears, cams, bearing races.		Medium-duty, high-strength applications, particularly in sections not over approx 2 in. thick. Gears, bolts, aircraft tubing, hand tools, shafts, forgings, etc.	

NOTES: [1] *Properties after heat treatment are based upon an oil quench and 1-in. round bars.*
[2] *Values for 8620 steel are for as-rolled stock. For 8630, 8640 and 8650 steels, values are for annealed stock.*

Prepared with the assistance of The International Nickel Co., Inc.

Mechanical TUBING SATISFACTION

for all machining and fabricating requirements

You have a wide choice of B&W MECHANICAL TUBING

TYPES—Seamless (hot finished, cold drawn or rocked.) Welded (from hot or cold rolled strip.)

GRADES—Carbon, Alloy, and Stainless Steels.

SIZES—Up to 9⅝" O.D. in full range of wall thicknesses.

QUALITY—Open-hearth and electric furnace steels, including aircraft and magnaflux qualities.

CONDITION—Unannealed, annealed, tempered, normalized, or otherwise heat-treated as required.

SURFACE FINISHES—As rolled, as drawn, as welded, flash removed, turned, scale-free, and polished.

SHAPES—Round, square, rectangular, oval, streamlined, and special shapes.

FABRICATION—Upsetting, expanding, bending, safe-ending, and machining.

A GOOD MAN TO KNOW

. . . Your B&W Tube Representative, because of his factory training in "tube technics" and specialized knowledge of applications may help you uncover tubing economies in buying and applying carbon, alloy, and stainless grades.

Say B&W before you say TUBES . . . for long-term service satisfaction and economy.

THE BABCOCK & WILCOX TUBE COMPANY

General Offices: Beaver Falls, Pa.

Plants: Alliance, Ohio, and Beaver Falls, Pa.

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Chicago 3, Ill. • Cleveland 14, Ohio • Detroit 26, Mich. • Houston 2, Texas
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St. Louis 1, Mo. • San Francisco 3, Calif. • Syracuse 2, N. Y.
Toronto, Ontario • Tulsa 3, Okla.

B&W SEAMLESS and WELDED TUBES

Materials Engineering File Facts

NUMBER 206
March, 1951

Alternate and Substitute Materials for Electrical Equipment and Parts

The substitute materials listed are suggested possibilities, and are not necessarily the best or only ones. Some may themselves become unavailable, depending on future conditions.

Part	Former Material	Substitute Material
Bearings, Motor	Bronze or babbitt	Iron-powder; silver lead; indium-plate
Bearings, Power Plant	Cast-iron anchored, thick tin-base babbitt	Thin-wall bonded tin babbitts
Boxes, Conduit	Brass, bronze	Coated steel
Boxes, Outlet Fittings	Brass, bronze	Coated steel
Boxes, Terminal	Aluminum castings	Wood; cast iron
Brushes, Carbon	Copper/graphite	Silver/graphite
Brush Holders	Aluminum die castings	Formed steel
Circuit Breaker Contact Arms, Cross Heads, Supports, Frames, Hooks, etc.	Aluminum castings	Steel
Commutator Riser Joints	Pure tin	Silver brazing
Conduit, Rigid	Galvanized steel	Blackened steel
Conduit and Cable Fittings	Brass, bronze	Painted steel
Contacts	Copper, copper alloys, copper/tungsten	Silver laminates; silver/molybdenum carbide
Floodlight Reflector	Polished aluminum	Silvered glass
Floodlight Socket Housing	Aluminum die casting	Magnesium or zinc casting
Floodlight Lens Ring	Aluminum stamping	Steel stamping
Floodlight Lens Ring Clamp	Brass	Steel
Furnace Elements	Nickel-chromium, nickel-chromium-iron	Silicon carbide iron-base alloy
Housings, Control	Aluminum	Steel
Housings, Street Light	Aluminum	Steel
Housings, Floodlight Socket	Aluminum die casting	Magnesium or zinc casting
Housings, Luminaire	Aluminum die casting	Cast iron
Lighting Reflectors	Aluminum stampings	Phenol plastic; silvered glass
Luminaire Hood	Aluminum die casting	Cast iron
Luminaire Reflector	Sheet aluminum	Silvered glass
Lightning Arrester—Casings and Fittings	Aluminum	Galvanized steel
Loading Pots	Copper	Lead
Magnets, Permanent	36% Co steel	17 Mo, 12% Co, iron alloy
Magnet Bearing Brackets	Aluminum die casting	Magnesium or zinc casting
Meter Bases	Aluminum die casting	Magnesium or zinc casting
Meter Nameplates	Aluminum	Fiber
Metal Sockets	Aluminum	Sheet steel
Meter (Watt-Hr) Cover Rings, Register, Seal Bar, Bayonets	Aluminum stamping	Steel
Nameplates	Aluminum paints, aluminum stamping	Gray lacquer etched zinc; lead alloy; cast iron
Pole Line Insulator Pins, Cross Arm Braces	Galvanized steel	Black-copper-bearing steel
Relay Covers, Frames, and Rotors	Aluminum castings	Steel
Resistance Windings (Cold)	Nickel-chromium iron, fine wire	Ceramic resistors
Resistors, Control	Nickel-chromium wire	Cast iron grids
Resistors, Furnace	Nickel alloy	Iron-base alloy; silicon carbide
Solders, Dip	60 Pb, 40% Sn	90 Pb, 10% Sn
Solder, Electrical (Heavy)	Pure tin	Silver brazing
Solders, Mechanical	60 Pb, 40% Sn	79 Pb, 20 Sn, 1% Ag
Solders, Wiping	62 Pb, 38% Sn	68 Pb, 23 Sn, 9% Cd
Street Light Housings	Aluminum	Coated steel
Street Light Brackets	Aluminum	Malleable iron
Street Light Hangers	Aluminum	Silicon bronze
Street Light Reflectors	Anodized aluminum	Silvered glass
Telegraph-Printer Bases	Aluminum	Cast iron
Telegraph-Printer Small Parts	Alloy steel	Carbon steel
Thermocouples	Chromium, Alumel	Platinum, platinum rhodium
Thermostat Elements	Nickel-steel, brass	Liquid expansion devices
Transformer Conductors	Copper	Silver or Silver laminates
Tubing, Metallic	Brass, bronze	Coated steel
Tuning Inductor Blocks	Aluminum	Plastic
Wire (Conductor)	Copper	Silver
Wire (Non-Conductor)	Copper	Steel

FORD
STUDEBAKER SPINNER HUB:
Erie Resistor Corp., Erie, Pa.;
Sobenite, Inc., South Bend, Ind.
FORD MEDALLION:
Hoosier-Cardinal Corp., Evansville, Ind.; Gits Molding Corp., Chicago, Ill.
CADILLAC MEDALLION:
Hoosier-Cardinal Corp., Evansville, Ind.
OLDSMOBILE TAIL LIGHT LENS:
Guide Lamp Division of General Motors, Anderson, Ind.
PONTIAC HOOD ORNAMENT:
Michigan Molded Plastics, Dexter, Mich.; Wolverine Plastics, Milan, Mich.
MERCURY INSTRUMENT PANEL:
Cruver Manufacturing Co., Chicago.
LINCOLN TAIL LIGHT LENS:
Erie Resistor Corp., Erie, Pa.

On '51 Cars

—MORE THAN EVER—

PLEXIGLAS

MOLDED PARTS

The photograph of these typical PLEXIGLAS automotive parts shows the beauty, but *not* the ease of molding—the sparkling appeal, but *not* the permanence of PLEXIGLAS. Remember this, too; *perfectionists* build America's motor cars. And PLEXIGLAS acrylic molding powders meet their rigid requirements! The demand for PLEXIGLAS molding powder currently exceeds supply. We suggest you investigate this material for your defense applications or for other future uses. Experimental quantities are available.

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

PLEXIGLAS is a trade-mark, Reg. U. S. Pat. Off. and in principal foreign countries.

Canadian Distributor: *Crystal Glass & Plastics, Ltd., 54 Duke St., Toronto, Ontario, Canada.*

New Materials and Equipment

Materials

New Resin Adhesive

Developed to allow users of Plaskon glue in the woodworking field to undertake government mobilization work with a glue meeting military requirements, a new phenolic resin for hot press plywood gluing that produces glue lines passing Army-Navy Aeronautical Specification AN-A-45 has been announced by the Plaskon Div. of *Libbey-Owens-Ford Glass Co.*, Toledo 6, Ohio.

Designated Plaskon 815-12, the resin is sold as a fine powdered material which can be extended up to 20% with walnut shell flour where cheaper mixes are desired.

The moisture content of woods glued with 815-12 is said to be critical, and moisture contents of 7 to 8% is recommended for optimum results. Standard pressures used with other synthetic resin glues are applicable. According to the manufacturer, 4 hr. of closed assembly will produce durable glue lines with little or no bleed through. Platen temperatures of about 290 F and sufficient press time are necessary to effect full cure of the resin.

New Polyvinyl Resin

A new, high molecular weight polyvinyl resin announced by *B. F. Goodrich Chemical Co.*, 324 Rose Bldg., Cleveland 15, is said to have created a whole range of applications in the fields of structural plastics and wire and cable insulation for polyvinyl materials.

Called Geon 404, the new resin is claimed to have the outstanding electrical, physical and chemical properties of pure polyvinyl chloride, and can be processed (extrusion, calendering or molding) successfully into rigids on conventional plastics equipment.

Sheets, rods and tubing of various diameters can be fabricated ranging from brilliant opaque to translucent, and in a wide color variety. Rigid sheets can be welded by the hot gas technique, then fabricated into fume hoods and ducts. Tanks for corrosives can also be made from it, in unsupported form, or as lining for metal tanks. In deep drawn and various welded forms it can be converted into pitchers, trays, funnels, buckets and barrels for use wherever an inert material is required. Other industrial equipment requiring this combination of machinable and chemical resistant plastic is said to include bearings, valves, gears, scoops, safety jugs and bottles, and laboratory furniture.

Under present emergency conditions, however, the new resin will be available in limited quantities and only for the development of military and other essential applications.

Rubber Plasticiser

Performance life of all rubber parts and surfaces which have hardened, cracked and become inelastic with age is said to be greatly prolonged by a new rubber plasticizer now available from *Schwartz Chemical Co., Inc.*, 326 W. 70th St., New York 23.

According to the manufacturer, when applied by cloth or brush to an old rubber surface, the new nonvolatile, noninflammable liquid plasticizes the rubber and imparts the feel, grip and resilience of new rubber.

It is claimed that rubber feed rollers, platens, friction wheels, teletype rolls, gaskets, hose, windshield wipers and other rubber products can be revitalized with Rub-R-Vive to give efficient service.

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Coatings & Finishes

Clear Lacquer

A new clear lacquer said to provide extreme durability and color stability has been introduced by *United Lacquer Manu-*

New Materials and Equipment
(CONTINUED)

facturing Corp., 1001 W. Elizabeth Ave., Linden, N. J. Developed to give a lasting rugged finish to school desks, cribs, tables, AO777A, when applied over sealer base 40916 on wood or other materials, is said to provide a tough film that resists abrasion and changes of color. United Lacquer has also announced a finish designed to permit dulling the reflecting surfaces of stainless steel in guided missiles, aircraft instruments and other apparatus. Designated VB 248, the new plastic synthetic finish was developed originally in black and in a dull finish. But, because of its good adhesion to highly polished surfaces, it is expected to find other applications where elimination of glare is not the primary objective.

Quick-Drying Enamel

A quick-drying enamel has been develope by the *Paint & Chemical Laboratory,* Aberdeen Proving Ground, Md. Based on the use of the new, quick-drying, styrenated-alkyd resins, the finish is expected to speed up production lines on army ordnance shells, bombs, grenades, and other munition components. The new specification, MIL-E-10687 (ORD), indicates that this enamel will set-to-touch in a maximum of 6 min and dry hard in 10 min. It is also claimed that this amazing acceleration in drying speed is accompanied by increased toughness, adhesion and resistance to salt spray and weathering.

Chromate Finishes

Alied Research Products, Inc., 4004-6 E. Monument St., Baltimore 5, has announced the addition of two new types of chromate finishes to their line of Iridites for bright finishing of zinc-plated surfaces. Marketed in powder form, as contrasted to most chromate compounds which are sold in liquid form, Iridite #8P is said to be extremely flexible and economical in use. The second finish, Iridite #12, is a chromate treatment for bright zinc plate that is said to both passivate and impart a chrome-like appearance to the slated surface. It is shipped in carboys in concentrated form. Iridite #12 provides relatively little chemical polishing action for the zinc, and thus should be applied only to bright zinc deposits. Both products are applied by a simple chemical dip method using standard finishing shop equipment.

Chromated Paints

The addition of three new chromated anti-rust paints to its Rustrem line of maintenance coatings has been announced by *Speco, Inc.,* 7308 Associate Ave., Cleveland 9. Known as Rustrem Chromate Special, the new paints, available in clear, black and aluminum, are said to possess all of the penetrating and sealing qualities of standard Rustrem. In addition, they contain liberal quantities of chromate pigment which, according to the manufacturer, is in itself an efficient rust inhibitive.

Applied over rust, without wire brushing or scraping, the new coating is said to be suitable for both interior and exterior use. An improved acid and alkali resisting black paint, Chem-Rem, by the addition of silicon, has also been announced by Speco. Suitable for both exterior and interior use on metal, masonry or wood, Chem-Rem is said to withstand attacks of acetic, hydrochloric and dilute sulfuric acids. Other features include imperviousness to moisture and high resistance to oil or oil fumes. Applied by brush, dip or spray methods, the paint is said to dry in 1 hr and set in 3 hr. Three coats are recommended for maximum protection.

Container Coating

A new coating now avaiabe from *Carboine Co.,* 7603 Forsyth Blvd., St. Louis 5, is Carbo-Kote 6020, a protective coating designed to eliminate baking coatings on steel tanks, or lining with 3/16-or 1/4-in. conventional lining materials, for handling acids, alkalis and solvents. Three brush-on coats of this coating is said to provide a lining 36 mils (0.036 in.) thick which is proof against a 30,000-v spark test and resistance to most solvents, acids and alkalis up to 350 F. Outstanding properties claimed for this new coating are:

Heat resistance: Withstands organic and inorganic acids, except nitric.

Adhesion: Adheres to wood, rubber, glass, porcelain, carbon and stoneware without a primer. Adheres to steel or concrete with the use of two prime coats of Carboline Primer #3.

*Hardness*s Has a durometer reading of 85 to 90, compared to steel of 100. In spite of hardness, flexibility is sufficient for tank lining service.

Heating, Heat Treatment

Core Baking Oven

Currently being offered by *Claud S. Gordon Co.,* 3000 S. Wallace St., Chicago 16, is a new core baking oven designed to meet the variety of requirements of foundry laboratory work. Of rugged

The Gordon-Campbell laboratory core baking oven consumes 1000 watts on 110 v, 1600 watts on 220 v.

construction, the Gordon-Campbell oven has a heavily insulated chamber 10 by 12 by 18 in. designed for maximum temperature of 550 F with sensitive, automatic, thermostatic control.

An additional feature of the new unit is a special double type air-diffusing system which is said to insure a large volume

Now, more than ever before, America must make full use of its steel-making capacity and conserve its natural resources. Now, more than ever, there is national significance in the phrases, *"Make a ton of sheet steel go farther"* and *"Make your product last longer."*

These low-alloy, high-tensile steels do "make a ton of sheet steel go farther"—for their inherently higher strength is 50% greater than mild carbon steel. That means, in turn, that 25% less section can be used with safety, and where rigidity is important, this can usually be compensated for through slight design change.

"Make your product last longer" is no idle claim. The much greater resistance of N-A-X HIGH-TENSILE to corrosion, abrasion, and fatigue assures longer lasting products even at reduced thickness.

Explore the potential economies to be derived from the use of low-alloy, high-strength steels—and then specify them. Their use can add materially to our national conservation program.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division, Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION

PRODUCER OF N-A-X HIGH-TENSILE STEEL

Remember

Ingersoll produces all **3**

Most users of Stainless-Clad steel know the 20-year record of IngAclad. Countless applications in all of the Process Industries have proved its dependability and real economy. Where protection has been needed on *both* sides of the metal, Ingersoll solid stainless sheets have also had wide acceptance.

But do you know that Ingersoll heat-resisting steels have also made an outstanding record in such applications as furnaces, ovens, etc., where excessively high temperatures are applied?

ENGINEERING B-W PRODUCTION

Ingersoll STEEL DIVISION
BORG-WARNER CORPORATION
310 South Michigan Avenue, Chicago 4, Illinois
Plant: New Castle, Indiana

New Materials and Equipment

of air to enter the oven with an equal amount of air intake at both the front and back of the chamber. In this way, with a minimum of three to four air changes per minute, convected heat is used to best advantage for drying and baking, rapidly eliminating the gases and moisture.

Crucible Tongs

Nearly 21 in. long and made of 18:8 stainless steel, the new crucible tongs manufactured by *Fisher Scientific Co.*, 717 Forbes St., Pittsburgh 9, are said to provide unusually safe handling of sample crucibles.

Designed to reach inaccessible and distant corners of most laboratory and furnace ovens, the tongs assure positive control by a unique, patented handle which provides separate grips for the thumb and one finger. To prevent the handles from slipping out of the alignment, joints of the tongs are flattened, while a snug fit with free joint action is assured since the rivet holding the flattened joints together is spun to exact tension.

Vacuum Furnace

Developed for such operations as heat treating, sintering, annealing, melting and pouring, the new vacuum furnace, Type 29-0410-18, announced by *National Research Corp.*, Cambridge 42, Mass., is a standard unit which operates at high temperatures and high vacuum or controlled atmospheres. A packaged unit with power supply vacuum pumping system, gages and controls enclosed in a metal cabinet, the furnace is said to require no additional equipment to put it into operation beyond the usual utilities. Contained in a water-cooled stainless steel sleeve, the heating element is said to have the following advantages:

1. High temperature—up to 3630 F with standard equipment.
2. Close control of temperature.
3. Even heat through the hot zone.
4. No refractories to outgas, which improves vacuum conditions and minimizes the hazard of contaminated critical melts.

FOR STAMINA AND LONG SERVICE

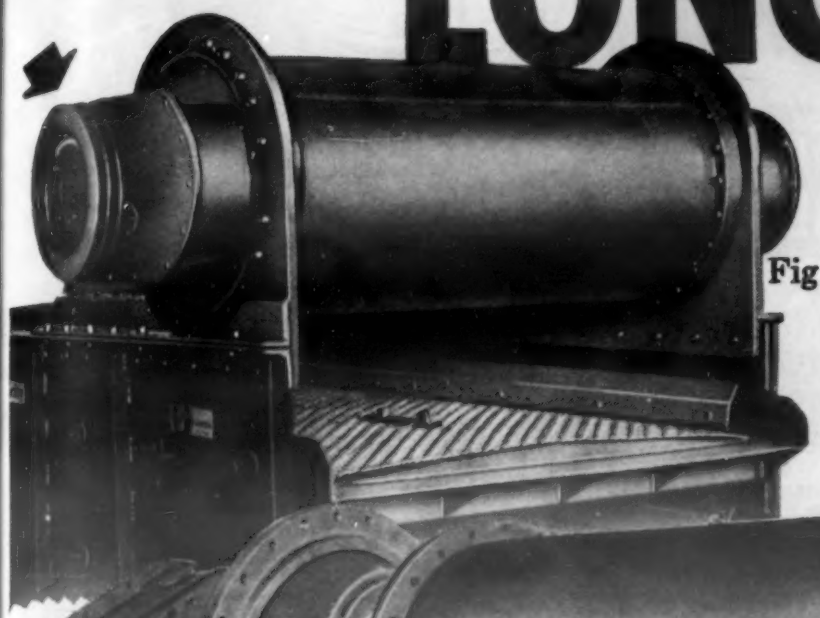


Fig. 1

Simplicity Engineering Co. *build with*

MEEHANITE CASTINGS

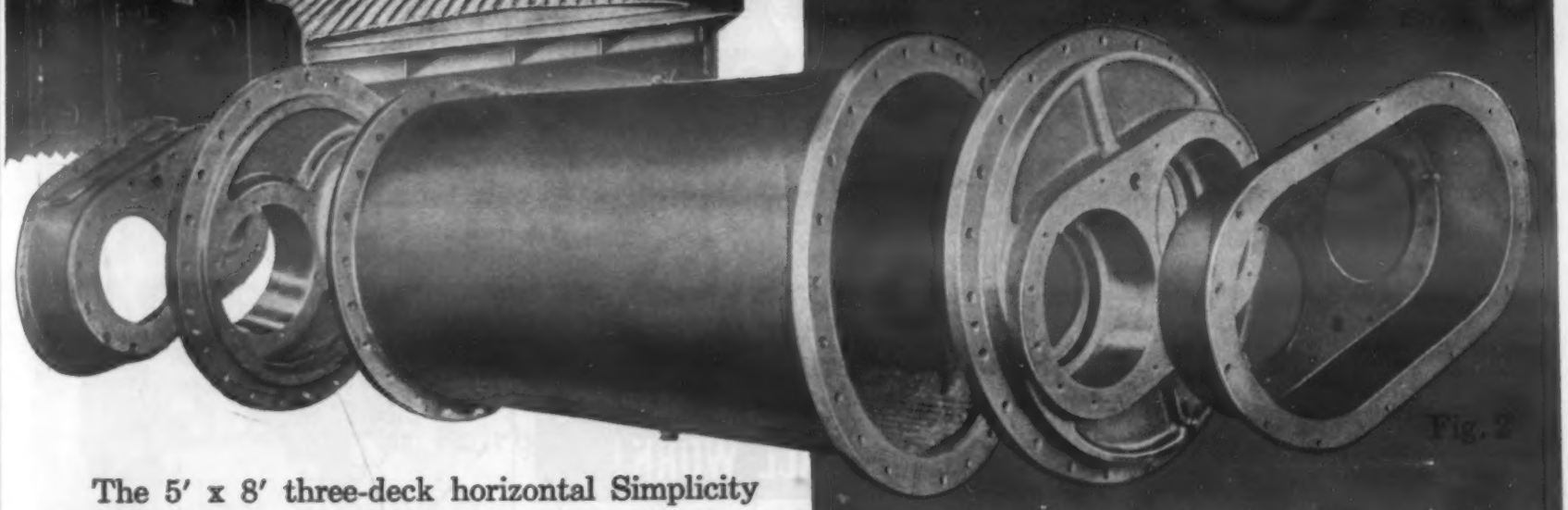


Fig. 2

The 5′ x 8′ three-deck horizontal Simplicity Screen (Fig. 1) is built with the Meehanite castings shown in Fig. 2. These are:

1. Tube End Plates
2. Gear Covers
3. Back Seals
4. V-Groove Sheave (arrow—Fig. 1)

Meehanite castings are used in the various Simplicity machines working under heavy duty conditions, in foundries, metallic ore plants, and in coal mining and aggregate producing plants. Rugged duty equipment requires rugged component parts, a condition fully met by Meehanite castings. They provide toughness, wear resistance, and adequate strength properties wherever used.

The advantages of Meehanite property controls can help your product. To be sure—specify Meehanite castings.

MEEHANITE®

NEW ROCHELLE, N. Y.

WHEN YOU NEED "EXTRAS" IN QUALITY OR PROPERTIES . . .
CONSULT ANY OF THE FOUNDRIES LISTED BELOW

American Brake Shoe Co. ..... Mahwah, New Jersey
The American Foundry Machinery Co. ..... Rochester, New York
Atlas Foundry Co. ..... Detroit, Michigan
Banner Iron Works ..... St. Louis, Missouri
Barnett Foundry & Machine Co. ..... Irvington, New Jersey
E. W. Bliss Co. ..... Hastings, Mich. and Toledo, O.
Bultinck Iron Foundry ..... Providence, Rhode Island
Continental Gin Co. ..... Birmingham, Alabama
Crawford & Doherty Foundry Co. ..... Portland, Oregon
The Cooper-Bessemer Corp. ..... Mt. Vernon, Ohio and Grove City, Pa.
Forrel-Birmingham Co., Inc. ..... Ansonia, Connecticut
Florence Pipe Foundry & Machine Co. ..... Florence, New Jersey
Fulton Foundry & Machine Co., Inc. ..... Cleveland, Ohio
General Foundry & Manufacturing Co. ..... Flint, Michigan
Greenlee Foundry Co. ..... Chicago, Illinois
The Hamilton Foundry & Machine Co. ..... Hamilton, Ohio
Johnstown Foundries, Inc. ..... Grove City, Pennsylvania
Kanawha Manufacturing Co. ..... Charleston, West Virginia
Lincoln Foundry Corp. ..... Los Angeles, California
F. Tetro Ltd. ..... Ottawa, Ontario
Otis Elevator Co., Ltd. ..... Hamilton, Ontario
The Rowe Foundry Co. ..... Bridgewater, Massachusetts
Pearson Foundry Co., Inc. ..... Buffalo, New York
Reliable Foundry & Machine Co. ..... Pittsburgh, Pennsylvania
Reliance Foundries ..... Chattanooga, Tennessee
Sandusky Foundry & Machine Co. ..... Sandusky, Ohio
Stanford Foundry Co. ..... Worcester, Massachusetts
The Stearns-Roger Manufacturing Co. ..... Denver, Colorado
Taylor Engineering & Mfg. Co. ..... Allentown, Pennsylvania
Walker Iron Works, Inc. ..... St. Paul, Minnesota
Western Foundry Co. ..... Oakland, California
Warren Foundry & Pipe Corporation ..... Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

UNIVERSITY OF MICHIGAN

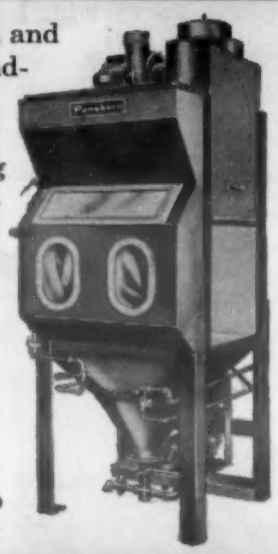
Here's BIG NEWS on Blast Cleaning Dust Control Precision Finishing

Blast Cleaning Unit is PORTABLE!

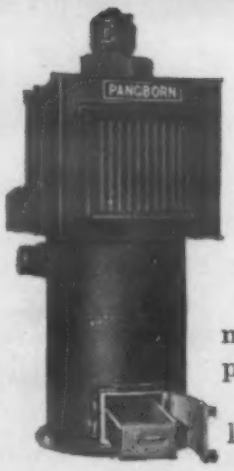
Ideal for maintenance and many other jobs, including removal of rust, dirt, scale, etc. Economically cleans large objects like tanks, bridges, structural work before painting. Six sizes, stationary or portable, from..... $170.00 and up

Hydro-Finish SPEEDS POLISHING!

Removes scale, and directional grinding lines . . . prepares surfaces for plating and holds tolerances to .0001"! Liquid blast reduces costly hand cleaning and finishing of molds, dies, tools, etc. Models from $1295.00 and up



STOP DUST at the SOURCE!



Pangborn industrial type Unit Dust Collectors trap dust at source. Machine wear is minimized, housekeeping and maintenance costs reduced. Solves many grinding and polishing nuisances and material losses. Models from $286.00 and up

COMPACT Blast Cabinet for SMALL WORK!

Ideal for producing smooth, clean surfaces on pieces up to 60" x 36" in size. Cleans metal parts, removes rust, scale, grime, dirt, paint, etc., in a few seconds. Saves money all year 'round. Models from $315.00 up

Look to Pangborn for the latest developments in Blast Cleaning and Dust Control Equipment

Pangborn MAIL COUPON FOR DETAILS

Check for more information

- ☐ Blast Cleaning Cabinets
- ☐ Blast Cleaning Machines
- ☐ Unit Dust Collectors
- ☐ Hydro-Finish Cabinets

PANGBORN CORP., 1700 Pangborn Blvd., Hagerstown, Md.

Gentlemen: Please send me more information on the equipment I've checked at the left.

Name.....

Company.....

Address.....

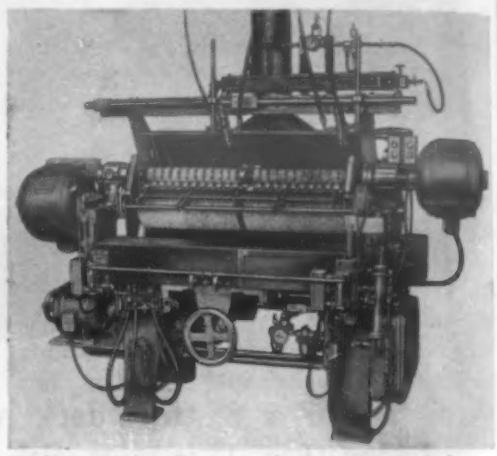
City.....Zone....State.....

New Materials and Equipment

Cleaning & Finishing

Surface Finishing Machine

Although developed through cooperation with several large silverware manufacturers, the new surface finishing machine introduced by *Clair Manufacturing Co.*, 1033 S. Union St. Olean, N. Y., is



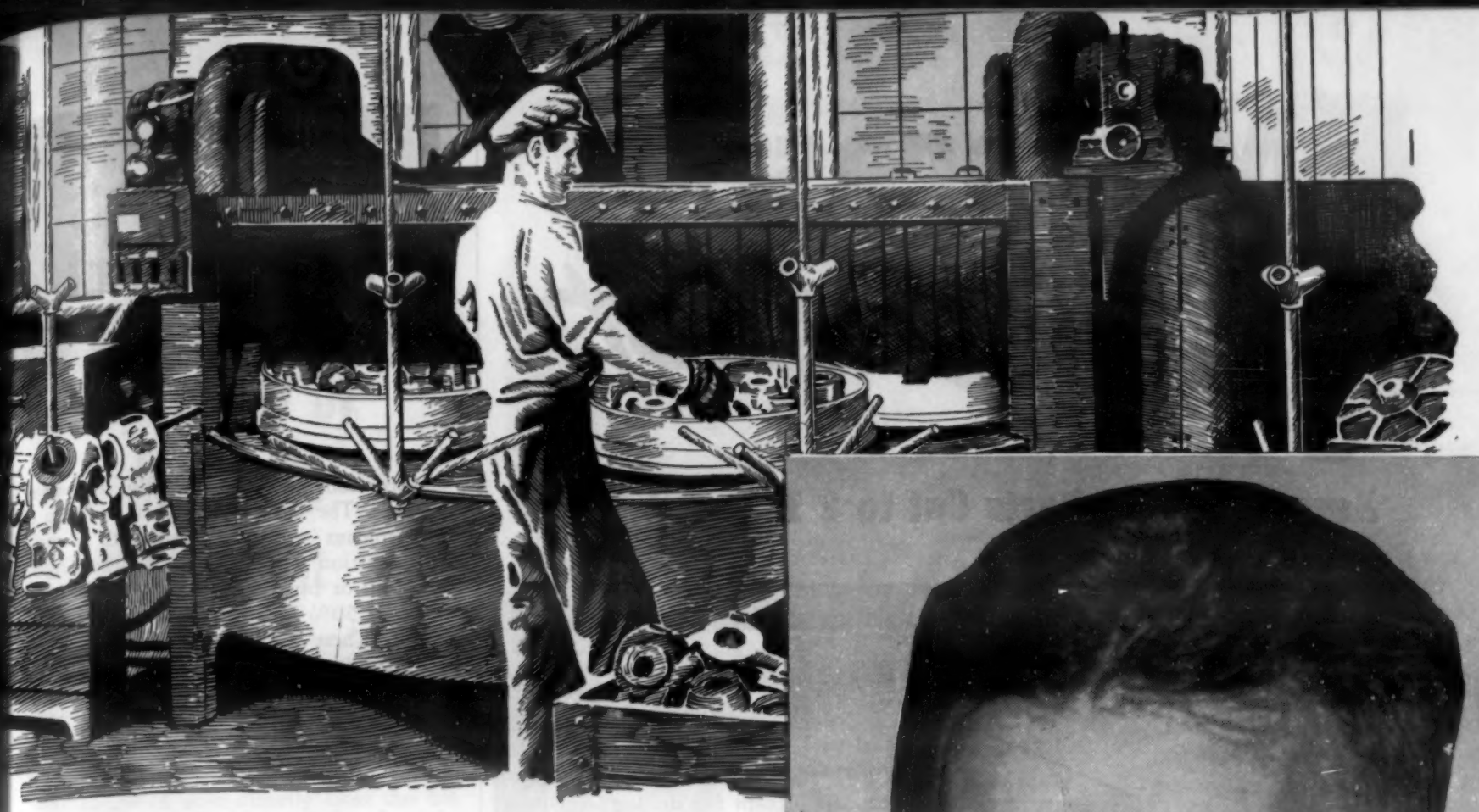
Adjustments for speed and magnitude on this surface finisher machine can be made without stopping the machine.

said to be applicable in other fields where similar contour problems exist.

Capable of simultaneous coverage both inside and outside of spoon and fork bowls and similarly shaped parts, the new Clair #204 features a high-waist design for ease in loading, and an electrohydraulic actuation system with totally enclosed hydraulic circuits which are said to be invulnerable to abrasives. A minimum working space 38 in. wide is provided by 40-in. length rolls in diameters up to 9 in.

Emulsion Cleaners

Recently developed in the laboratories of *Northwest Chemical Co.*, 9310 Roselawn, Detroit 4, this new cleaning process for all metals utilizes emulsion cleaners of the W/O type, based on petroleum products to replace hot chlorinated solvent degreasing. In effect, this system is said to be equivalent to spraying the work with solvent, while immersed in water, rather than in the air. Since these emulsions are unstable, mechanical agitation (induced by propeller type mixers or by a pump and jet system) is required to maintain



M. F. Putz, Foundry Superintendent of Fairbanks, Morse

ROTOBLAST*

Ends Cleaning Room DOWN-TIME

at Fairbanks, Morse

PANGBORN ROTOBLAST pays off at the Freeport Works of Fairbanks, Morse with *no work stoppages* in the cleaning room. As M. F. Putz, Foundry Superintendent puts it: "ROTOBLAST gives us good service with nominal repair. We like it!"

And the record backs him up. Castings with hard-to-clean pockets are cleaned down to virgin metal . . . with tiny cracks and imperfections exposed, which saves time on inspection time and rejects. One man plus the ROTOBLAST Table and Barrel handles the entire cleaning load (25,000 pounds of *small* castings) per 8-hour day!

ROTOBLAST can save you money on blast cleaning. *Look to Pangborn for the latest developments in blast cleaning and dust control equipment.*

More than 25,000 Pangborn Machines Serving Industry

Here's the Key to Low-Cost, High-Quality Blast Cleaning

Pangborn ROTOBLAST saves from $5000 a year to $50,000 a year. Specifically, ROTOBLAST builds savings these five ways . . .

SAVES LABOR: One ROTOBLAST machine and operator can do as much as, or more than, a two-man crew and old-fashioned equipment.

SAVES SPACE: In many cases, one ROTOBLAST machine replaces five or more old-fashioned machines.

SAVES TIME: Cases on record prove ROTOBLAST can cut cleaning time up to 95.8%.

SAVES POWER: Modern ROTOBLAST uses but 15-20 h.p. compared to 120 h.p. needed by old-fashioned equipment.

SAVES TOOLS: On work cleaned with ROTOBLAST, cutting tools last up to 2/3 longer because no scale is left to dull edges.

SEND FOR FREE BULLETIN! All ROTOBLAST machines are covered in Bulletin 214. Write for your free copy to: Pangborn Corporation, 1700 Pangborn Blvd., Hagerstown, Md.

Pangborn

BLAST CLEANS CHEAPER

with the right equipment for every job

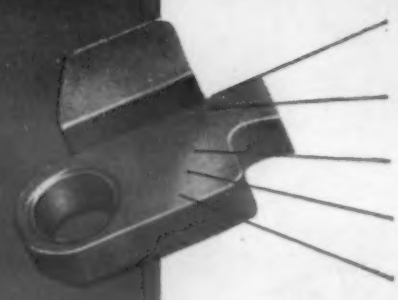
*Trademark of the Pangborn Corporation

FOUNDRY EQUIPMENT MANUFACTURERS ASSOCIATION INC. MEMBER FEMA

Microcast®
Slashes Cost

Assembly of 6 Parts Cut to 2 Integral Parts

CLUTCH STOP PAWL



Microcast as 1 piece; formerly 4 piece assembly.

Used as cast, except for drilling and reaming one hole.

Sound structure — dimensionally uniform.

Milling operation and assembly eliminated.

Microcasting reduced cost on this part 20%.

DRUM LOCK PAWL

Microcast as 1 piece; formerly 2 piece assembly.

Used as cast, except for drilling and reaming one hole.

Special form cutters, gages, jigs, etc. eliminated.

Milling operation and assembly eliminated.

Microcasting reduced cost on this part 75%.

MICROCAST TRADE MARK REG. U. S. PAT. OFF.

MICROCAST PRECISION CASTINGS PROCESS

MICROCAST offers design engineers many opportunities for product improvement of small components with substantial savings in cost. High melting point, non-machineable, non-forgeable alloys can be specified for economical quantity production, too. Write for complete information.

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AUSTENAL LABORATORIES, INC.
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715 East 69th Place, Chicago 37, Illinois

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Get your copy of this all-inclusive 16-page booklet on Microcastings. Write today!

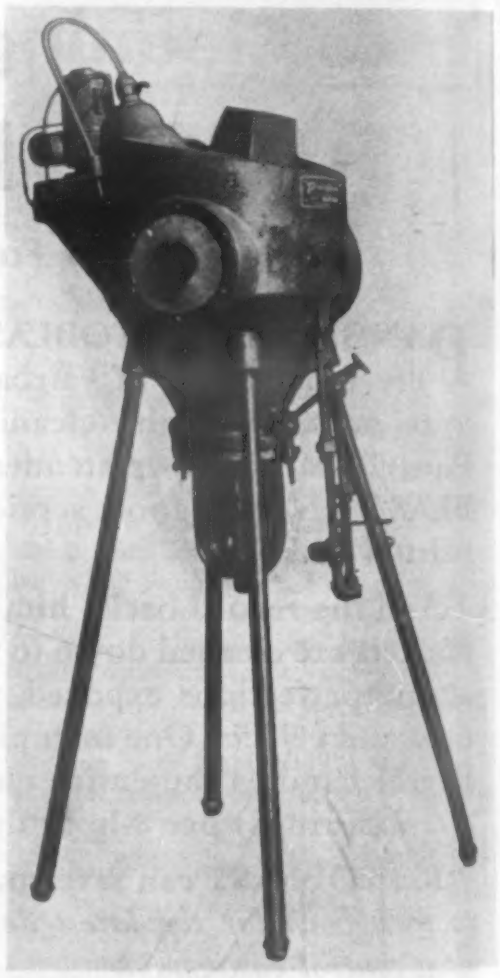
MICROCAST

New Materials and Equipment

dispersion of the solvent in the water phase. The two-phase bath is built up of petroleum solvent treated with a small proportion of Northwest Addition Agent #230 or by adding directly to the water 10 to 50% Northwest Emulsion Cleaner #3. These baths can be heated to the maximum of 160 F, depending upon the solvent used.

Liquid Blast Cleaning Unit

A new 40-lb. midget unit for liquid blast cleaning, operable from either a ¼-in. compressed air line or any bottle of compressed gas, has been announced by *Pangborn Corp.*, Hagerstown, Md.



This new small blast cleaning unit requires only 17 by 22½ in. of floor space and can be bench mounted if desired.

Designed to bring to makers and users of tools, dies, fixtures and molds a small portable device for occasional work and small parts, the aluminum-housed unit can be used for:

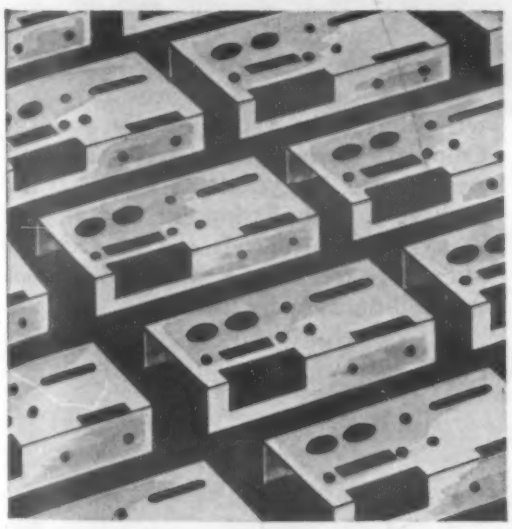
1. Die and mold polishing after heat treatment.
2. Precision part polishing.

Fingerprints and Water Stains On Copper Plate Prevented by Water Dip Treatment

The common problem of fingerprinting, water staining and oxidation on copper plated surfaces has been effectively solved by the use of Water Dip #33 for applying a protective coating to the copper plate. This treatment is extremely economical, since the work goes directly from the hot water rinse into the Water Dip tank, without any need for intermediate drying and rehandling.

Speeds up soldering

Application of Water Dip #33 not only does not interfere with subsequent soldering (as in the wiring of radio chassis, but actually improves and speeds up the operation. The coating prevents the usual formation of metal oxides while parts are in storage prior to wiring, and in most cases the electrical resistance of Water Dip #33 is no higher than the oxides would offer.



5,000 radio chassis were copper-plated by one manufacturer and dipped in Water Dip #33. There were no rejects after riveting and soldering operations.

Less risk of error

While Water Dip #33 is colorless as supplied, dyes can readily be added for identification of terminals or other parts. This gives quick visual identification that simplifies the job of connecting wires to the right terminal, and saves inspection time.
Water Dip #33 is produced by Maas & Waldstein Company, Newark 4, N. J., and is described in Technical Data Bulletin #117, available from the manufacturer.

(ADV.)

Copper-plated Parts Stay Bright and Clean

when the plating shop treats them with WATER DIP #33

● Forced to switch from cadmium plating to copper plating —on the parts you *finish* or on the parts you *buy?*

Then you'll want the full story on a simple, low-cost metal treatment that *keeps* the copper surface bright and chemically clean—just as it comes from the plating bath. *M & W Water Dip # 33 prevents finger printing and staining during assembly, storage and use.*

If you're doing copper plating, you can cut out extra operations by using Water Dip #33. Work goes *directly* from the last hot water rinse into Water Dip #33—no need for rehandling and drying!

If you're using copper-plated parts, you'll find that you can make excellent soldered connections—or strong, uniform welds even after the parts have been dipped in Water Dip #33.

Water Dip #33 has many more advantages—in many types of plating. For the complete story, write for Technical Data Bulletin #117, or let our M & W technical consultant discuss your requirements privately with you.

PIONEERS IN PROTECTION

75th ANNIVERSARY • M&W CO. 1876

MAAS & WALDSTEIN COMPANY

NEWARK 4, N. J.
CHICAGO 12, ILL.
LOS ANGELES 34, CAL.

PACIFIC COAST DIVISION: SMITH-DAVIS CO., 10751 VENICE BOULEVARD, LOS ANGELES 34, CAL.

MANUFACTURERS OF INDUSTRIAL FINISHES

Keep in Step with—
RIGID GOVERNMENT
TUBING REQUIREMENTS
SPECIFY "Standard"
for Welded Stainless Steel Tubing
The Heat Exchanger exemplifies one of the severest uses for stainless tubing. "Standard's" stainless tubing meets this, as well as many other different requirements for strength, and heat and corrosion resistance.
Deal with the Specialist among Specialists
A tubing specialist, like other specialists, knows his trade best.
When you deal with "Standard" you deal with a tubing specialist who manufactures millions of feet of tubing every month from stainless and carbon steel—and for 25 years has been serving all types of industry for mechanical and pressure tubing applications.
If you need stainless tubing, be sure you specify "Standard". It pays to deal with the tubing specialist among specialists.
Stainless Tubing Size and Thickness
⅜" O.D. to 3" O.D.
.028 to .095 wall
Carbon Steel Tubing
½" O.D. to 5½" O.D.
.028 to .260 wall
THE STANDARD TUBE CO.
Detroit 28, Michigan
Welded Tubing
Fabricated Parts
STANDARDIZE with STANDARD — It Pays

New Materials and Equipment

3. Surface treatment better to hold light lubricating oil films.
4. Preparation for plating.
5. Cleaning of parts which function at high temperatures.
6. Stain and light scale removal.

Called the Number 0 Type EZ Hydro-Finish Blast Cabinet, the new unit is said to use the same wide range of abrasives (as fine as 5000 mesh) on blasted parts to within 0.0001 in.

Metal Degreasing Solvent

Currently availabe from *Colonial Alloys Co.*, Philadelphia 29, a powerful metal degreasing solvent for both ferrous and nonferrous metals is said to speedily remove oils and greases as well as solid soils containing oils and greases from all types of metal surfaces. A free-flowing, free-rinsing fluid, Tricyclodiene can be used at room temperature as a dip, spray or wipe, and usually followed by rinse in a clean solvent. This solvent can be perchlorethylene, trichlorethylene or carbon-tetrachloride in vapor or dip form, or Colonial Methanated solvent at room temperature. Tricyclodiene solvent is said to have a high flash-point and is rated as a safety solvent. It can be reclaimed after it is spent by means of distillation and additions, or by filtration.

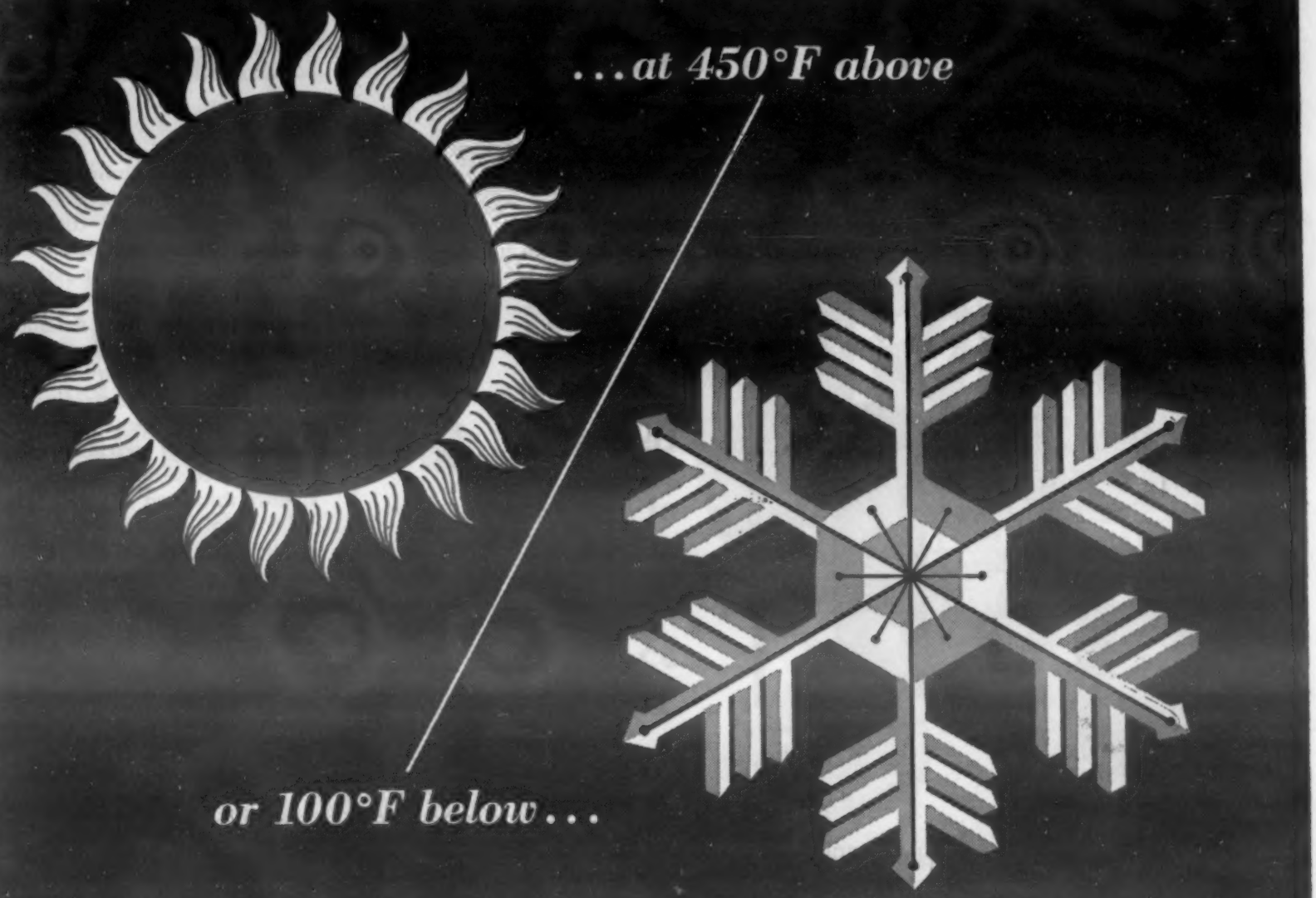
●

Welding & Joining

Mash Resistance Welder

Developed by *Sciaky Brothers, Inc.*, 4915 W. 67th St., Chicago 38, the new PMM 2TL press type mash welding machine is designed for the specific application of joining a 28-in. width of mild steel sheet to form a continuous line for various mill operations. Mash welding, a relatively new process of resistance welding technique, employs the use of either a seam or projection type welder to obtain a smooth end-to-end joint without metal

Cellular Rubber that Works*



* *Silicone Spongex* Stock 9727

Is your product headed for altitudes never reached by commercial aviation? For climates where refrigerators, television sets and pleasure cars refuse to function? And on top of that . . . must you have insulation against shock, sound and vibration or against the passage of dust, air, temperature or moisture? Such a product will need cellular rubber components.

In the range from the soft, porous *Spongex* used as an iron lung collar seal to the rigid, featherweight *Spongex Cell-Tite* used as a carburetor float may be found the answer to your problem. If not, we'll work it out for you.

SPONGEX®

CELLULAR RUBBER

PARTICIPATING IN THE MANAGEMENT AND FINANCING OF KENTUCKY SYNTHETIC RUBBER CORPORATION

The World's Largest Specialists in Cellular Rubber

THE SPONGE RUBBER PRODUCTS COMPANY

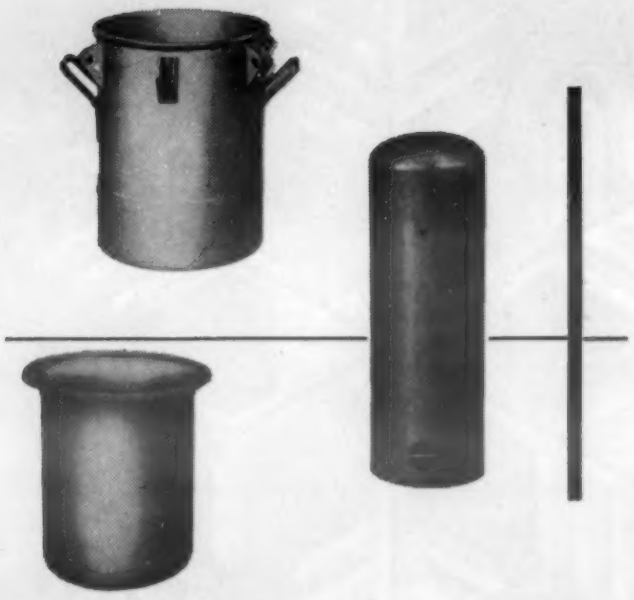
403 DERBY PLACE, SHELTON, CONN.

UNIVERSITY OF MICHIGAN LIBRARIES

Prest-O-Lite
Trade-Mark

Cold-Drawn SHAPES and SHELLS

made to your specifications by *Linde*



Leaders of the Field for Over 35 Years

PREST-O-LITE cold-drawn shapes and shells can be quickly and economically produced to your most rigid specifications—from 1½ to 23 inches in diameter and up to 50 inches in depth. Our greatly expanded, well-equipped plant has every modern manufacturing facility and is manned by a thoroughly experienced, highly specialized staff—prime requisites of a quality product.

LINDE engineers will gladly help you solve your production and design problems involving cold-drawn shells, cups, containers, receivers, pressure vessels, formed parts, or other shapes.

The term "Prest-O-Lite" is a trade-mark of Union Carbide and Carbon Corporation.

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A DIVISION OF UNION CARBIDE AND CARBON CORPORATION

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Linde Air Products S17
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

Please send literature and full information about cold-drawn shapes and shells.

NAME_____

COMPANY_____

ADDRESS_____

New Materials and Equipment

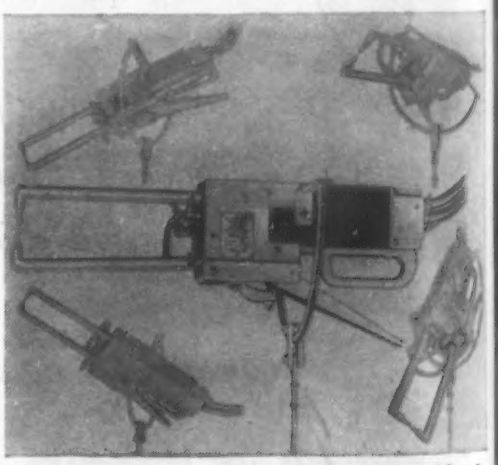
overlap or protruding metal on the joined edges of the sheets.

In contrast to the conventional seam welding where the sheets are usually overlapped 3/8 to 1 in., the amount of overlap in this process is limited to approximately 1½ times the sheet thickness with welding pressure correspondingly increased to almost twice that for conventional seam welding—thus forcing the plastic metal without any irregularities or metal ejection from an overlap of two sheets into a single sheet only slightly thickened at the welding joint.

In actual operation of the new mash welder, it is said the operator has only to insert the ends of the sheet to be welded to a stop between the electromagnetic clamping bars and depress a control button which clamps the sheets securely and rocks the clamped piece parts with a pre-adjusted overlap to the welding position.

Portable Spot Welder

A third addition to the series of welders is the new 10-kva and 20-kva portable spot welder now being manufactured by *Miller Electric Manufacturing Co.*, Appleton, Wis. Equipped with ball bearing suspension ring, and weighing approximately 80 lb, the new unit is said to be extremely low in cost.

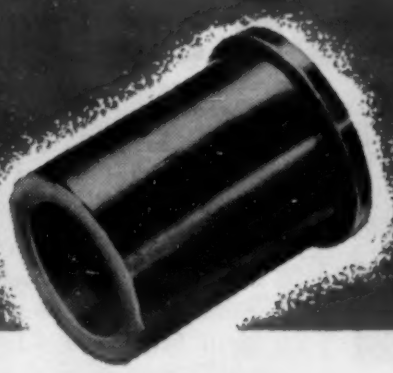


This new low-cost portable spot welder is said to provide ease of operation.

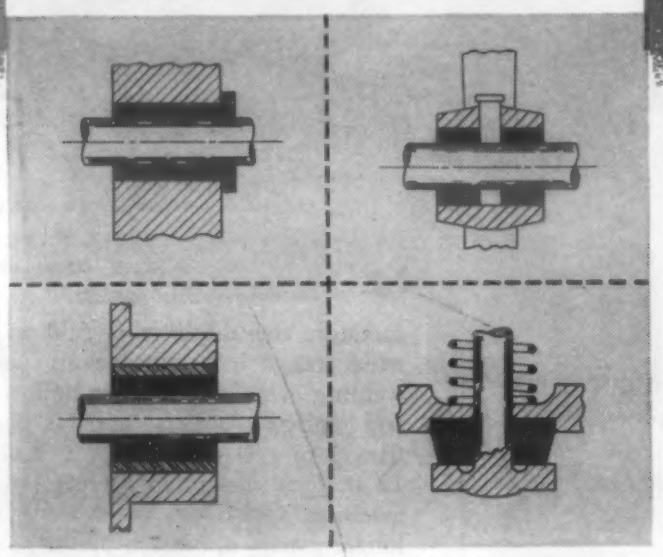
Hidden Arc Seam

Another type of welder, recently announced by *The Cecil C. Peck Co.*, Cleveland, is an automatic hidden arc standard

non-contaminating



MORGANITE
SELF-LUBRICATING
BEARINGS



— for pumps, mixers, grinders, agitators, food and enameling oven conveyors, etc.

Here's a practical solution to problems of contamination caused by conventional lubrication. Morganite Self-Lubricating Bearings require no attention—never need oil or grease because the lubricating qualities are inherent in the material itself. These bearings impart no taste or odor, are unaffected by chemicals and most acids and are completely efficient at relatively high speeds and temperatures. Find out, now, how Morganite can cut your maintenance costs, reduce shutdowns of production equipment.

Also available for general industrial purposes, Morganite can be supplied in various grades for seals, rings, vanes and other applications. All are self-lubricating, self-lapping and polishing.

SEE OUR CATALOG in Sweet's File for Product Designers. Call or write for complete engineering data or recommendations on specific problems. Estimates will be supplied promptly on receipt of specifications.

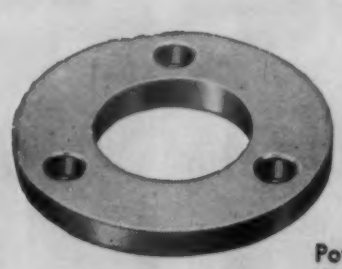
see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

REGISTERED TRADE MARK

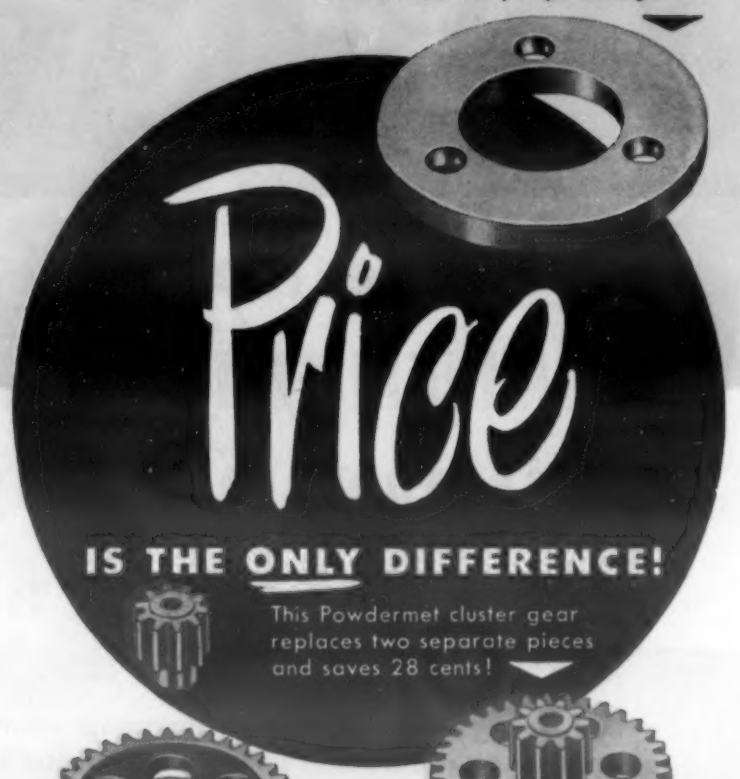
Morganite INCORPORATED

LONG ISLAND CITY 1, NEW YORK

Manufacturers of CARBON MOTOR and GENERATOR BRUSHES, CARBON PILES and SELF-LUBRICATING CARBON SPECIALTIES



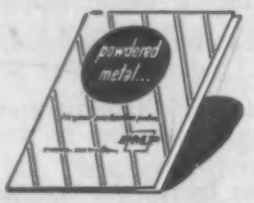
Powdermet production saved 400% on this pump housing!



POWDERMET* PARTS

Cost Less!

"Matched pairs" like these... actual production parts, one produced by conventional methods and one Powdermet, identical in precision and performance...prove the amazing economies made possible through Powdermet fabrication. And when special properties like electrical permeability or controlled porosity are important, Powdermet parts offer functional advantages too! Exclusive Powdermet production techniques have extended the application of powder metallurgy to whole new production fields—helical gears, stress members, filters—write today for the free booklet shown here and see how you can save with Powdermet parts!



SEND FOR THIS FREE BOOKLET

Check Powdermet advantages for your gears • filters • cams • pole pieces • ratchets • tuning cores • keys • latches • bearings • pawls • sprockets • valves • switch parts

PMP

POWDERED METAL PRODUCTS CORPORATION of America

9335 West Belmont Avenue
Franklin Park, Illinois

*Trademark

COMPARE

your present

ALUMINUM FINISHING PROCESS

with these advantages of

IRIDITE® Al-Coat

—see for yourself why more and more finishers of aluminum products are specifying Iridite Al-Coat for any wrought, cast or buffed aluminum part.

1. IN PROCESSING

Faster—Just one simple dip, 10 seconds or only two minutes, depending upon your finishing specifications. No sealing dip, no special drying.

Simpler—Non-electrolytic, no heating or exhaust units, operates at room temperature. No special precleaning baths required.

2. IN APPEARANCE

Clear—Protects metal without changing its original appearance.

Colored—Heavier, iridescent yellow film provides greater protection.

3. IN PERFORMANCE

Corrosion Resistance—Up to 1,000 hours salt spray on wrought stock, 250 hours on castings. Approved under government specifications.

Abrasion Resistance—Will not flake or peel from buffing, bending or scraping.

Paint Base—Blocks underfilm corrosion; grips paint, holds it firmly.

Welding—Finished surface can be spot welded, coating actually aids shielded arc welding.

Conductivity—Offers low surface resistance to electrical current.

4. IN COST

Comparative figures show that Iridite Al-Coat saves as much as 50% over other aluminum finishing processes. *Let us prove this to you.*

Write today for FREE SAMPLES of Iridite Al-Coat. Or, send samples of your product for test processing.

Iridite is approved under government specifications.

ALLIED RESEARCH PRODUCTS
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REPRESENTATIVES IN PRINCIPAL INDUSTRIAL CITIES; West Coast: L. H. BUTCHER COMPANY
Manufacturers of Iridite Finishes
For Corrosion Resistance and Paint Systems for Non-Ferrous Metals; ASTM Finishes Available

New Materials and Equipment

seam welder for automatically welding seams in metal ranging from 14 gage to ¼ in. Employing a Lincolnweld head and

This standard seam welder can be used for automatic brazing or inert-gas-shielded arc welding on stainless steels and non-ferrous metals.

carriage, the machine is said to have a wide range of applications, including welding cylinders or other hollow shapes, and splicing sheets and through-weld flanges in making containers. Work up to 18 ft. long is said to be handled by this machine, which can be extended to take longer pieces; minimum diameter is 12 in.

●

Forming & Machining

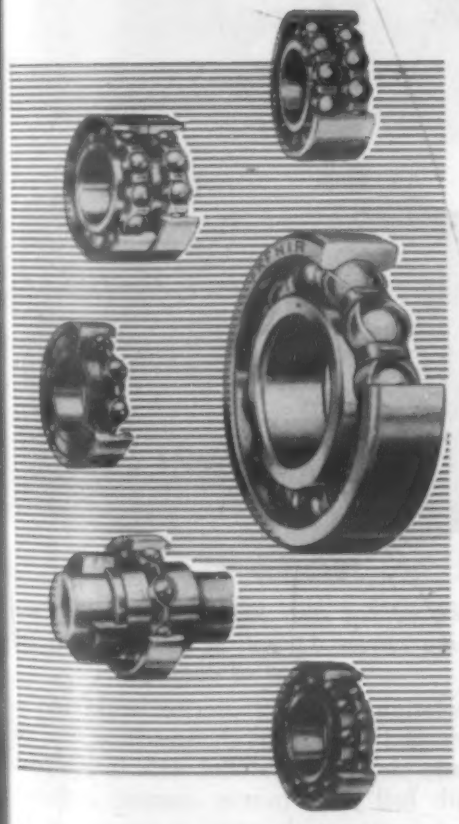
New Honing Machine

Designed to meet the requirements of firms who desire to finish longer bores from ¼ to 4 in. in dia than is possible with the Model 412, the new Model 415 honing machine is said to have a working stroke of 15 in. and a capacity from ¼ to over 4 in.

Manufactured by *C. Allen Fulmer Co.*, Cincinnati, the new machine carries a 1¼-in. dia heat treated alloy steel spindle driven by a 3-hp motor through alloy steel reduction gears, with three spindle speeds available. Reciprocation is hydraulic with a 2-hp motor driving a Vickers pump with Vickers controls that permit reciprocating speeds from 1 to 70 ft per min.

Engineered for heavy duty, constant

HERE'S HOW...



FAFNIR USES 20 LINDBERG CYCLONES

...to draw thousands of types of bearings!

The Fafnir Bearing Company, New Britain, Conn., uses Lindberg Cyclone Furnaces to draw thousands of types and sizes of its line of ball bearings. They say:

"The metallurgical department of our company entrusts the major part of its drawing operations to Lindberg Cyclone Furnaces because it has found them to be dependable work horses. At the present time there are 20 in use in the Company's three ball bearing plants in New Britain, Conn.

"They have given excellent continuous service for more than 8 years. For long periods they were operated 24 hours a day, seven days a week, (at temperatures ranging from 275 to 1200°F.) without downtime due to furnace failure.

"Because the Fafnir line of ball bearings,comprising thousands of types and sizes, is considered the most complete manufactured in this country, the Lindberg Cyclones draw a considerable variety of parts. The work varies from small to large dense loads (up to 1600 lbs.) of bearing rings, balls and rolls, yet the uniform results demanded for the manufacture of precision products is constantly being achieved—and in an atmosphere of cleanliness and satisfactory working conditions."

Local Offices in every industrial center.

LINDBERG ENGINEERING COMPANY 2451 W. Hubbard Street, Chicago 12, Illinois.

LINDBERG FURNACES

Now Available

NEW CLASS H*

MOTORS PROTECTED BY DOW CORNING SILICONES

. . . the insulation that has already saved industry millions of maintenance dollars plus the hourly output of hundreds of thousands of men!

This most timely announcement caps the test program we started 8 years ago when silicone resins were introduced by Dow Corning Corporation. First we proved by accelerated life testing that silicone insulated motors had a good 10 to 1 advantage in life expectancy and wet insulation resistance. Then we sold silicone (Class H) insulation to the manufacturers of electrical equipment ranging from lift truck and traction motors to solenoid and brake coils. We also encouraged the better rewind shops to rebuild hard working industrial motors with Class H insulation.

Now we can proudly refer American industry to this goodly list of electrical manufacturers, all able and willing to supply electric machines protected by Class H insulation made with Dow Corning Silicones.

Take your special problems to the application engineer representing any of these companies or to our Product Development Engineers.

furnished by:

ALLIS-CHALMERS MANUFACTURING COMPANY

Continental Electric Co., Inc.

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The Reliance Electric & Engineering Company

THE B-A-WESCHE ELECTRIC COMPANY

WESTINGHOUSE ELECTRIC CORPORATION

THE MASTER ELECTRIC COMPANY

* "Class H" insulation is the kind of insulation that keeps motors running in spite of "Hell and High water." *(language dictionary)*

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

DOW CORNING SILICONES

Atlanta • Chicago • Cleveland • Dallas • Los Angeles • New York • Washington, D. C.
In Canada: Fiberglas Canada Ltd., Toronto • In Great Britain: Midland Silicones, Ltd.

New Materials and Equipment

The welded steel base of this honing machine carries 52 gal of hydraulic oil and 45 gal of coolant.

operation on small precise work, and so arranged that job change-overs can be made easily, the Model 415 is equipped with full push button control, including push button withdrawal at the end of the cycle.

New Presses

Production of a new four-in-one, 4-ton punch press has been announced by *Kenco Manufacturing Co.*, 5211 Anaheim-

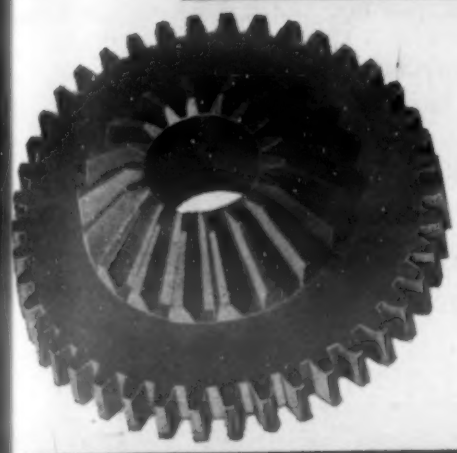
In Powder Metal they cost 80% less!

Products of Powdered Metal Products Corporation of America, Franklin Park, Illinois, specialists in gear making.

Bevel gear for power drill

Each of these gears is prohibitively expensive to make by conventional machining operations. In powder metal, each is formed at a single stroke.

The small bevel gear for a power drill has a tensile strength of 100,000 psi. Savings in powder metal: 8 machine operations, 86% of total cost.



Spur and mitre gear for business machine

The mitre gear is used in a business machine. Savings in powder metal: 15 machining and assembly operations, 80% of total cost.

Helical and spur gears for transmission in washing machine

The helical and spur gear are used in an automatic washing machine transmission. Savings in powder metal: 18 machining and assembly operations, 88% of total cost.

To these and many other parts difficult or costly to form, powder metal processing is rapidly extending its many economies. Consult Stokes, makers of powder metal presses, on powder metal possibilities. Send parts or blueprints for report by Stokes engineers on their adaptability to powder metal processing.

A comprehensive booklet "Powder Metallurgy Today" will be sent on request.

STOKES

STOKES MAKES

Plastics Molding Presses,

Industrial Tabletting

and Powder Metal Presses,

Pharmaceutical Equipment,

Vacuum Processing Equipment,

High Vacuum Pumps and Gages,

Special Machinery

F. J. STOKES MACHINE COMPANY, 5972 TABOR ROAD, PHILADELPHIA 20, PA.

Maintenance Cost Problem Solved...

with Fullergript Brushes

"The Fibers Did Not Fly Out of the Brushes as with Previous Brushes"

Back in 1942 one progressive leather manufacturer saw, in the construction of Fullergript brushes, a possible solution to his problem of "keeping the fibers from flying out of the brushes". Fullergript engineers were asked to design and build a plate washing brush. It was necessary to experiment with different core diameters, different brush materials and different trim lengths. The result was the first successful application of the Fullergript plate washing brush — a brush which has since been widely adopted by tanneries.

Alert management, by capitalizing on the far greater density of Fullergript, had enhanced the thoroughness of brushing and increased brush life, and thanks to Fullergript's unique construction had a brush where "the fibers did not fly out as with previous brushes".

Fullergript is increasing production and saving time and money in a variety of industries. Have you investigated the advantages of Fullergript for your own plant? To learn how Fullergript can help you, simply write to . . .

FULLERGRIPT The FULLER BRUSH CO.

INDUSTRIAL DIVISION
3636 MAIN STREET
HARTFORD 2, CONN.

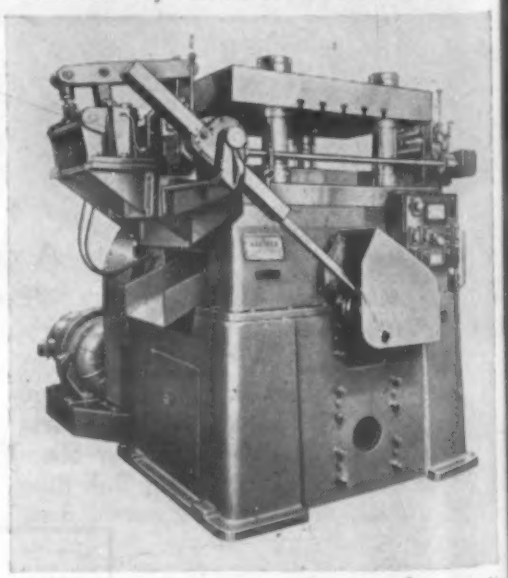
New Materials and Equipment

Telegraph Rd., Los Angeles. Outstanding features of the new press are a deep 12¾-in. throat and a sturdy 400-lb cast frame and patented clutch drive dog built into the clutch collar instead of a slot in the crankshaft. An adjustable bed is said to

This punch press features a trip mechanism permitting the operator to change from single to continuous ramming without stopping the machine.

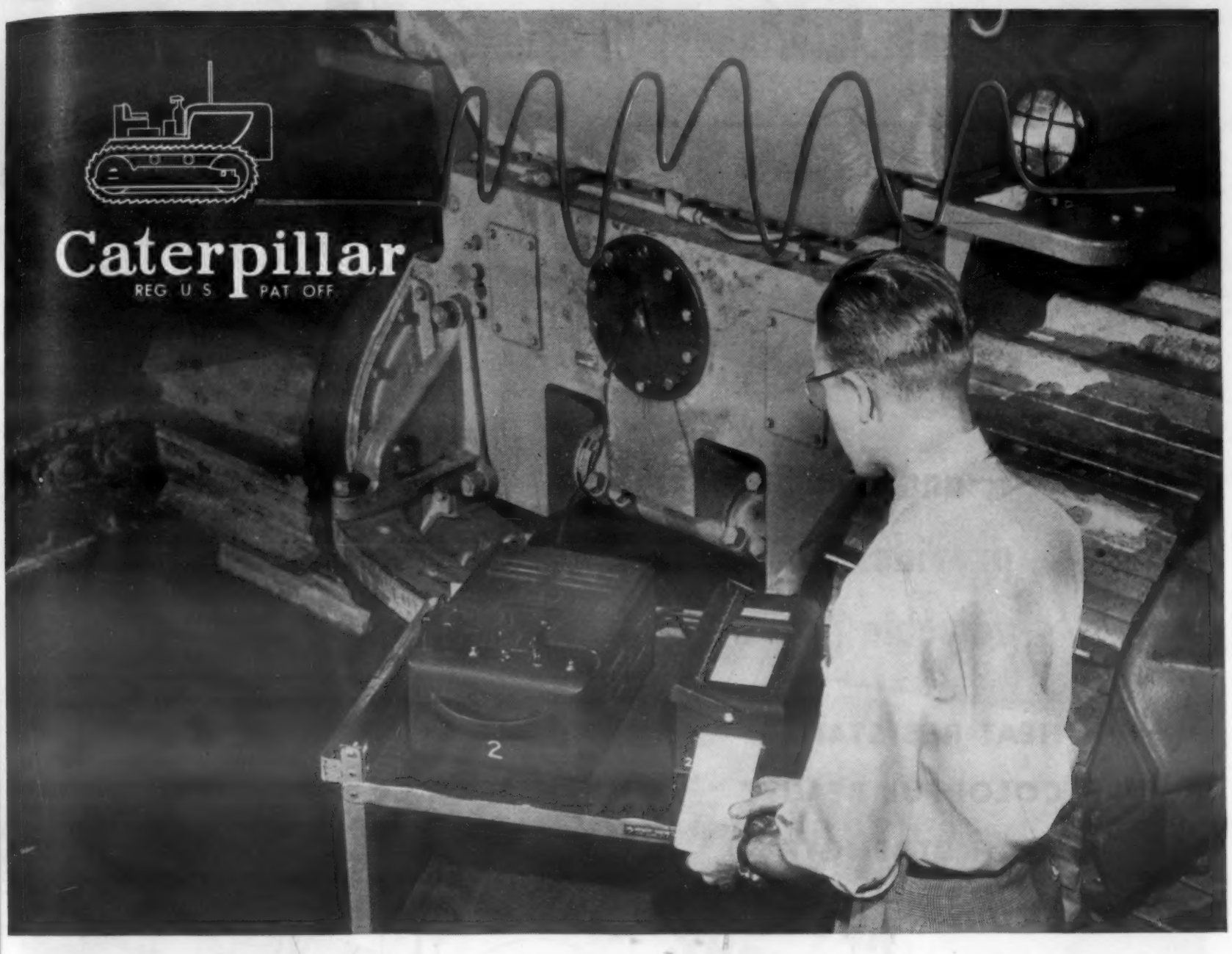
permit quick conversion from the standard press to a long punch, half or horn press.

The addition of a complete line of wide bed automatic presses, ranging in size from 30 to 2,500 tons, was recently announced by *Brandes Press Co.*, 6408



This 175-ton press takes strokes up to 10 in. while a speed of up to 250 strokes per min is said to be obtainable.

Euclid Ave., Cleveland 13. Built to Joint Industrial Conferences' standards, including T slots in the top platen and remote control of the variable speed drive, the 175-ton wide bed press features a die clearance of 28 in. from front to back by 60 in. from right to left. Roll feeds have a



Records dynamic strains of moving engine parts with BRUSH Analyzer

● At Caterpillar Tractor Co., research engineers are constantly seeking to improve performance of engines and components. To do so requires immediate, accurate data of dynamic phenomena. That's where the Brush Strain Analyzer comes in.

In this test on tractor parts, strains are "picked up" with bonded electric strain gages. The signal is amplified in the Brush Universal Amplifier and recorded instantaneously on the Brush Direct Writing Oscillograph.

Other current projects in the "Caterpillar" Research Department are utilizing Brush Strain Analyzers for determining operating stresses in engine parts and components. Set-ups for such tests are laborious and expensive, consequently only the most reliable and precise instruments are used.

With use of a resistance-sensitive pick-up, the Brush Strain Analyzer provides a complete package unit for obtaining permanent records of torque, strain, vibration, pressure and other variables. Write today for further information.

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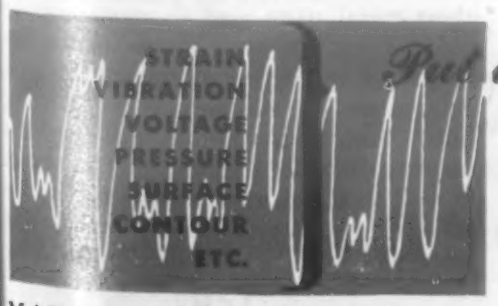

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BRUSH RECORDING ANALYZER

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All of these properties you can translate into effective *sales* points, for they give greater beauty and utility to products employing glass.

Kopp specializes in the design and manufacture of glass components, precision-made to customers' specifications. We will be glad to discuss with you, the possibility of using Kopp glass in your products.

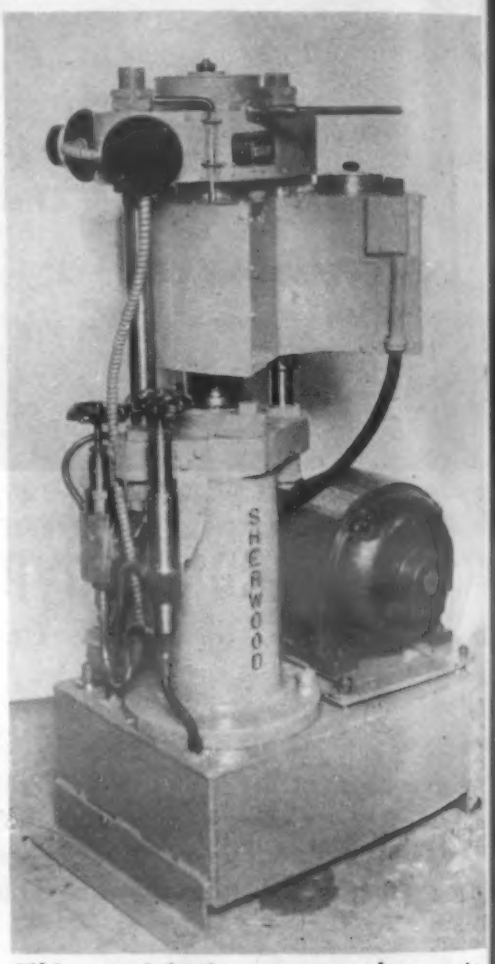
KOPP GLASS

KOPP GLASS, Inc.
SWISSVALE, PA.

New Materials and Equipment

3-in. vertical adjustment and are said to take material up to 18 in. in width.

Another addition to the press line is the Model WP12 wax injection press manufactured by *Sherwood Metal Products Co.*, and distributed by Alexander Saunders & Co., 95 Bedford St., New York 14. Designed for the production of wax and plastic patterns for Precision investment castings, the new press, an improvement over the Model WP11, has a temperature range to 400 F; ram pressure, varying with the power of the motor, to 1500 psi



This wax injection press employs a separate heating unit for the crosshead and discharge nozzle to facilitate free flow of pattern material.

can be developed. Total capacity for the press is said to be about 268 cu in.

Developed by *Birdsboro Steel Foundry and Machine Co.*, Birdsboro, Pa., a new 5,000-ton hydraulic press is said to feature unusual flexibility of operation. Designed originally for cold rubber-pad forming of sheet metal parts used in airplane frame construction, the press is now making hot-forged parts for earth-moving machines. In construction, the press is single action, with both push-button and sensitive manual control. A quick reversal feature is said to make its operating cycle desirable for hot-forging work, minimizing wear and tear of the dies by avoiding

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New Materials and Equipment

prolonged control of the hot metal with the dies.

Metallurgical laboratory operators will be interested in the new No. 1330 AB speed press announced by *Buehler Ltd.*, 165 W. Wacker Drive, Chicago 1. With a 10,000-lb. capacity, this new press is designed to provide the metallurgist with a new tool for the speedy and practical preparation of mounted specimens in either opaque Bakelite or crystal clear plastic compounds. Molds, heating and cooling blocks are said to be quickly interchangeable for the various size requirements: 1-, 1¼-, and 1½-in. mountings.

New Casting Method

Practi-Cole Products, Inc., 333 E. Street, New Haven, Conn., has developed a rapid method for casting beryllium copper mold cavities in sizes up to 2 in. sq., 2½ in. round in very fine finish and intricate detail. The only requirement from the customer is a model of the part to be molded or a sample cavity to be duplicated. According to the manufacturer, in most cases up to 12 cavities can be furnished in as-cast condition within one week.

Other services provided by Practi-Cole include embossing, marking and gold stamping dies for the graphic arts and allied industries.

●

Testing & Control

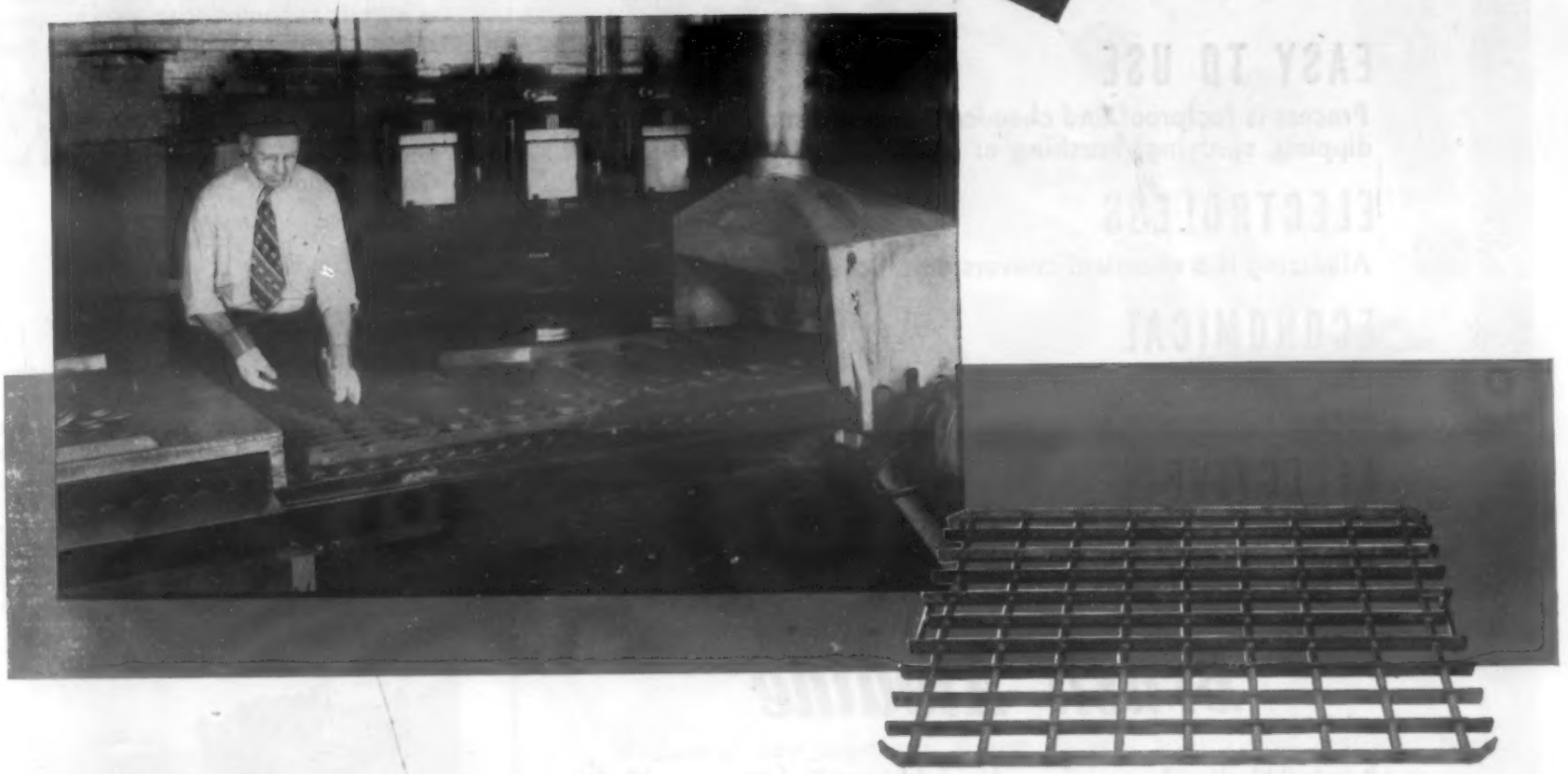
Electronic Vibration Recorder

Designed for the study of vibration, strain and dynamic stresses, the new self-contained electronic unit introduced by *Electronic Tube Corp.*, 1200 E. Mermaid Lane, Philadelphia 18, is said to record phenomena up to 50 kc and amplify these weak signals up to 35,000 times.

Known as the H-42A Strainanalyzer, the unit is claimed to make possible the simultaneous observation and recording of four separate traces on a single 5-in.

ROLOCK

FABRICATED HEAT AND CORROSION RESISTANT ALLOYS



ARTICULATED TRAYS *for highest resistance* *to* WARPING . . . UNDER EXTREME TEMPERATURES

The photograph above shows an installation of furnace trays built by Rolock for National Stamping Company, Detroit, Michigan. They are used in a General Electric roller hearth furnace operating at 2050 degrees on copper brazing and at 1600 to 1800 degrees on bright annealing.

Flat bar construction of the 60 lb. tray with bent outer bars, to avoid catching on roll guides, gives optimum performance with loads 100 lbs. and over. Hot rolled bars prevent scoring of furnace rolls . . . flexible construction eliminates warping and cracking. Handles at ends also serve to index cover screen for small parts. The carefully checked performance proves the importance of job-engineered design for a specific condition.

If you are experiencing tray troubles . . . short service life, cracking, warping . . . ask Rolock engineers for recommendations. We can cut your heat-hour costs and improve processing. Catalog and Bulletin on request.

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Easier Operation, Lower Cost

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Process is foolproof and chemical solution can be applied by dipping, spraying, brushing or flow-coating.

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Alodizing is a chemical conversion process.

ECONOMICAL

Low chemical cost, short coating time and low temperature keep overhead down.

EFFECTIVE

The tough, durable Alodized surface makes paint stick to aluminum and resists corrosion. "Alodine" meets these Service specifications: MIL-C-5541; MIL-S-5002; AN-E-19; AN-F-20.

Brush Alodine®

Brush "Alodine" is easily and quickly applied to assembled aircraft in the field, shop, or hangar. Cleaning and coating chemicals for Brush Alodizing are shipped in bulk or in the convenient Brush "Alodine" Chemical Kit No. 1. This Kit contains enough chemicals to treat about 1000 square feet of surface and is an ideal package for use at airfields of commercial airlines or of the Armed Services anywhere.

Use "Alodine" and Alodized Aluminum for Maximum Product and Finish Durability!

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New Materials and Equipment

oscilloscope tube, each appearing in correct time relationship without necessity of optical alignment.

As a typical application, the Strainanalyzer can be used to check relative pressures at four different parts of a gun barrel. Other uses range from strain, stress and vibration studies in such equipment as aircraft and automotive units to presses, internal combustion engines, and all rotating and reciprocating mechanisms.

Highly compact, and with all controls readily accessible on a single panel, the new unit is said to offer savings in both time and money.

Thickness Gage

Designed for rapid checking of sheet and strip stock, the Model 644 portable thickness gage manufactured by *Federal Products Corp.*, 1144 Eddy St., Provi-

This Model 644 portable thickness gage is designed for rapid checking of sheet and strip stock.

dence 1, R. I., is said to reduce inspection costs to a minimum.

Some of the diversified functions claimed for this gage are:

1. Checks incoming material to insure receipt of proper stock sizes.
2. Assures issuance of correct sheet thickness from stock room to manufacturing for stamping, blanking, drawing and forming.
3. Measure stock before and after plating operation to determine thickness of plating.

Measurement is said to be quickly and accurately transferred to the Model G81 full-jeweled dial indicator, graduated 0.0001 in., through the hardened steel upper and lower contact points. The indica-

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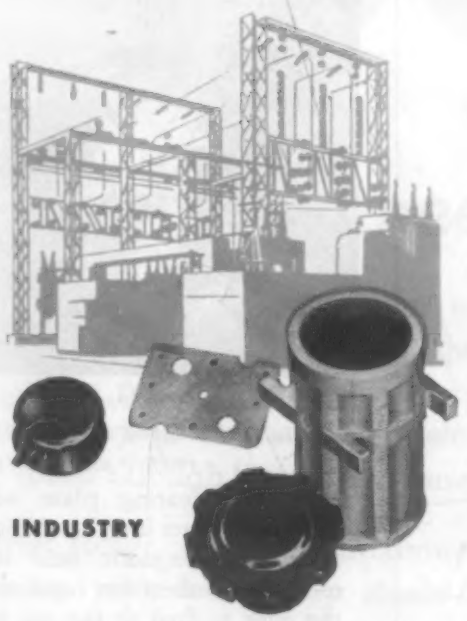

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MICARTA® can take any shape. It is a tough and resilient basic material . . . a plastic which can be machined, formed or molded to micro-fractions of an inch.

MICARTA is lighter than aluminum. Pound for pound, it has a greater compressive strength than structural steel. It cushions impact, resists heat and cold, outlasts metal in many punishing applications.

Here is an excellent insulator. It is a standard in panels, switch handles, separators...wherever electric current has to be isolated.

This versatile basic material fabricates easier and more economically than any metal. Do you have a place for it? Westinghouse Electric Corporation, MICARTA Division, Trafford, Pennsylvania.

J-06447

And what is "Duralizing"?

It's a surface treatment given to the casting

1 . . . to make it more resistant to abrasion
2 . . . to make it more resistant to molten metal
3 . . . to minimize "pick up"

This is a treatment we developed in our own laboratory and foundry to meet special conditions for certain furnace operations. Normal high alloy castings would withstand the heat all right but abrasion, erosion and pick up were something else again. The "Duralized" Rolls solved the problem.

While you may not need a high alloy casting calling for the Duralizing treatment, you may have a high alloy casting problem. We'll be glad to study it with you and recommend the alloy and type of casting best for your requirements.

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New Materials and Equipment

tor can be furnished with a direct or continuous reading dial, depending upon the use of the gage.

●

General

Magnetic Sheet Separator

Difficulty in separating sheets of steel for feeding into stamping presses and press brakes is said to be eliminated by means of a new moderately priced, nonelectric, permanent-type plate magnet unit recently announced by *Verson Allsteel Press Co.*, 9326 S. Kenwood Ave., Chicago 19.

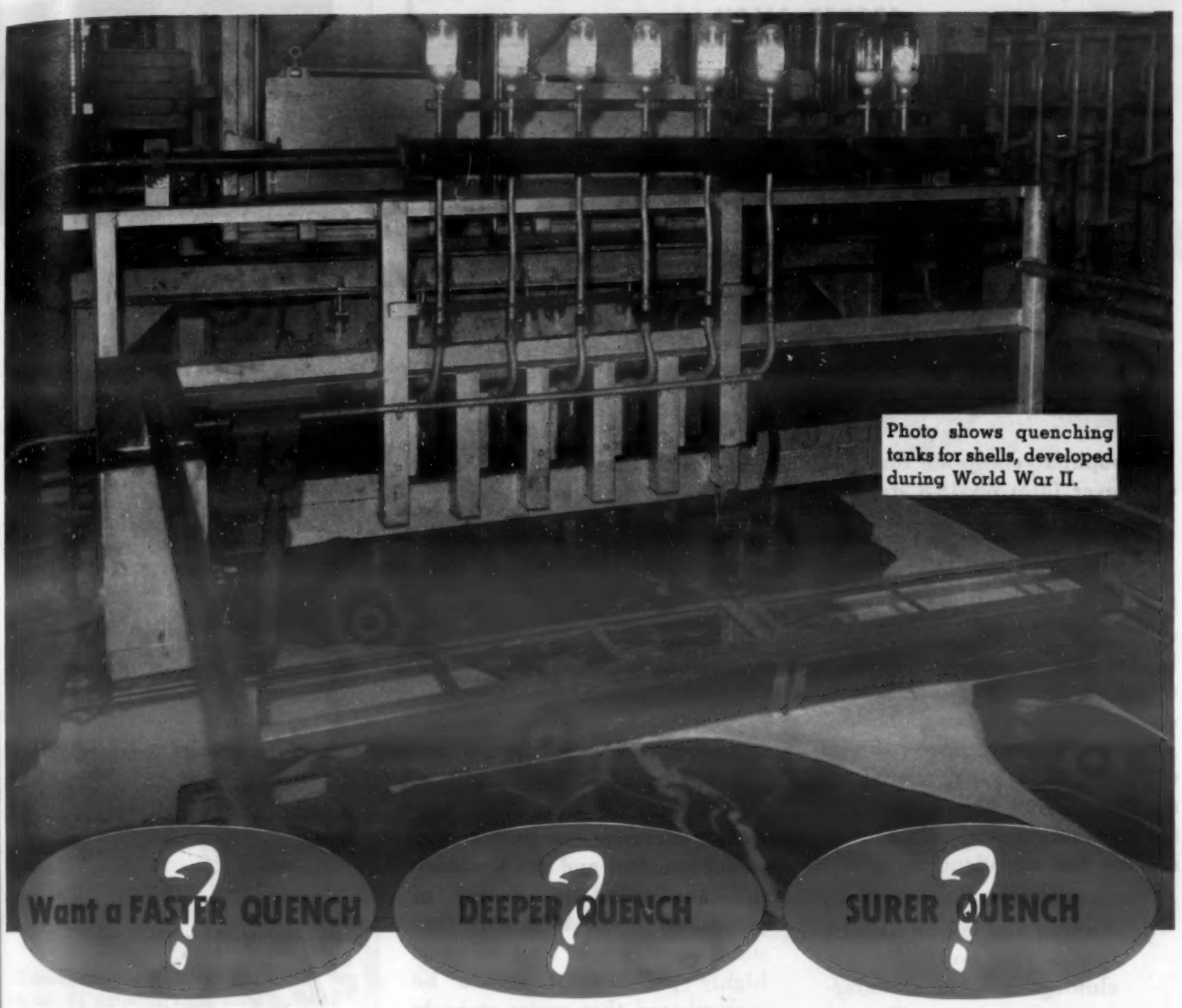
In construction, the Sheet Floater consists of powerful Alnico magnets, a stainless steel mounting bracket and a stain-

This magnetic sheet separator is said to substantially speed up sheet handling and reduce cut injury.

less steel wearing plate welded into a single, compact unit. In principle, the unit induces a magnetic field in the sheets, causing the sheets to repel each other and the ends to float or fan out with air space between them. Separated in this manner, the top sheet is said to be easily grasped by the operator and fed directly into the press.

Metal Separators

Three new models of Eriez permanent (nonelectric) magnetic separators and electronic metal detectors have been an-



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That's the oil that saved the day for so many metalworking plants during the critical shortage of alloying elements in World War II, by giving them a faster quenching speed through the critical zone.

Now it's even faster, assuring maximum hardness even with lean alloy steels—again a necessity.

Houghto-Quench is stable and long-lived. It may well be the answer to your quenching problem. Ask the Houghton man, or write us direct. E. F. Houghton & Co., Philadelphia 33, Pa.

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Technical Topics

RUST FORMATION ON 18-8 STAINLESS STEEL

Norman S. Mott
Chief Chemist and Metallurgist

The popular conception that rust can never form on 18-8 stainless steel, unless something is wrong with the chemical composition or the heat treatment, is a long way from the truth. Experience has shown that rust can occur on stainless alloys of controlled composition and heat treatment as the result of surface contamination. Among the many sources of contamination which may contribute to the formation of rust on the surface of stainless steels, the following are leading offenders:

1. An iron film left on the surface as the result of a machining or other manufacturing operation will tend to rust in the presence of moisture.

2. Microscopic scale particles left on the surface after pickling may become visible as "rust" under suitable conditions.

3. Pickling solution oozing from minute pores in the metal may stain the surface and oxidize to a brown rust color due to the iron which it contains.

4. The accumulation of the natural corrosion products of the alloy in corrosive service on a rough surface may cause a brown stain due to oxidation.

5. Discoloration may be caused by the accumulation of any extraneous processing material which is of such a nature as to cause a "rusty" appearance on a rough surface.

Articles that are to have a truly "stainless" appearance should have all scale completely removed by suitable cleaning methods, should be passivated after machining operations in warm dilute nitric acid, should be free from porosity, and should have a reasonably smooth surface.

A smooth or polished surface will always stay cleaner and brighter, and be more resistant under mildly corrosive conditions than a rough surface and this tendency increases with the degree of polish. Although it is true that stainless steel is at its best when highly polished, it should be remembered that under strongly corrosive conditions this polish is soon removed. For most applications, it is the inherent resistance of the alloy that counts and "rust" conditions such as those described are relatively harmless. They are the results of surface contamination and in no way reflect the composition of the alloy or the effectiveness of the heat treatment.

Available on request

Detailed technical chart giving comparative designations, analyses, properties and applications of stainless, corrosion and heat resistant alloy castings.

COOPER ALLOY
Stainless Steel
VALVES · FITTINGS · CASTINGS

New Materials and Equipment

nounced by *Eriez Manufacturing Co.*, Erie, Pa.

One of the units is a plate-type separator powered by Alnico magnets and known as ATOMagnets. Available in three different models, each with a different magnetic strength, these separators are said to provide protection from tramp iron damage by removing ferrous tramp metal before it can do any harm.

Another type of separator, which can be installed anywhere that belt conveying equipment exists, is the ATOMagnet pulley, which is said to automatically separate tramp iron from nonferrous materials such as coal, sand and gravel.

An RCA electronic metal detector, sold nationally by Eriez, is claimed to discover any ferrous or nonferrous metal that becomes imbedded in materials. Installed on assembly lines, it warns of the foreign matter in raw material, materials in process and in finished products by ringing a bell or displaying a light.

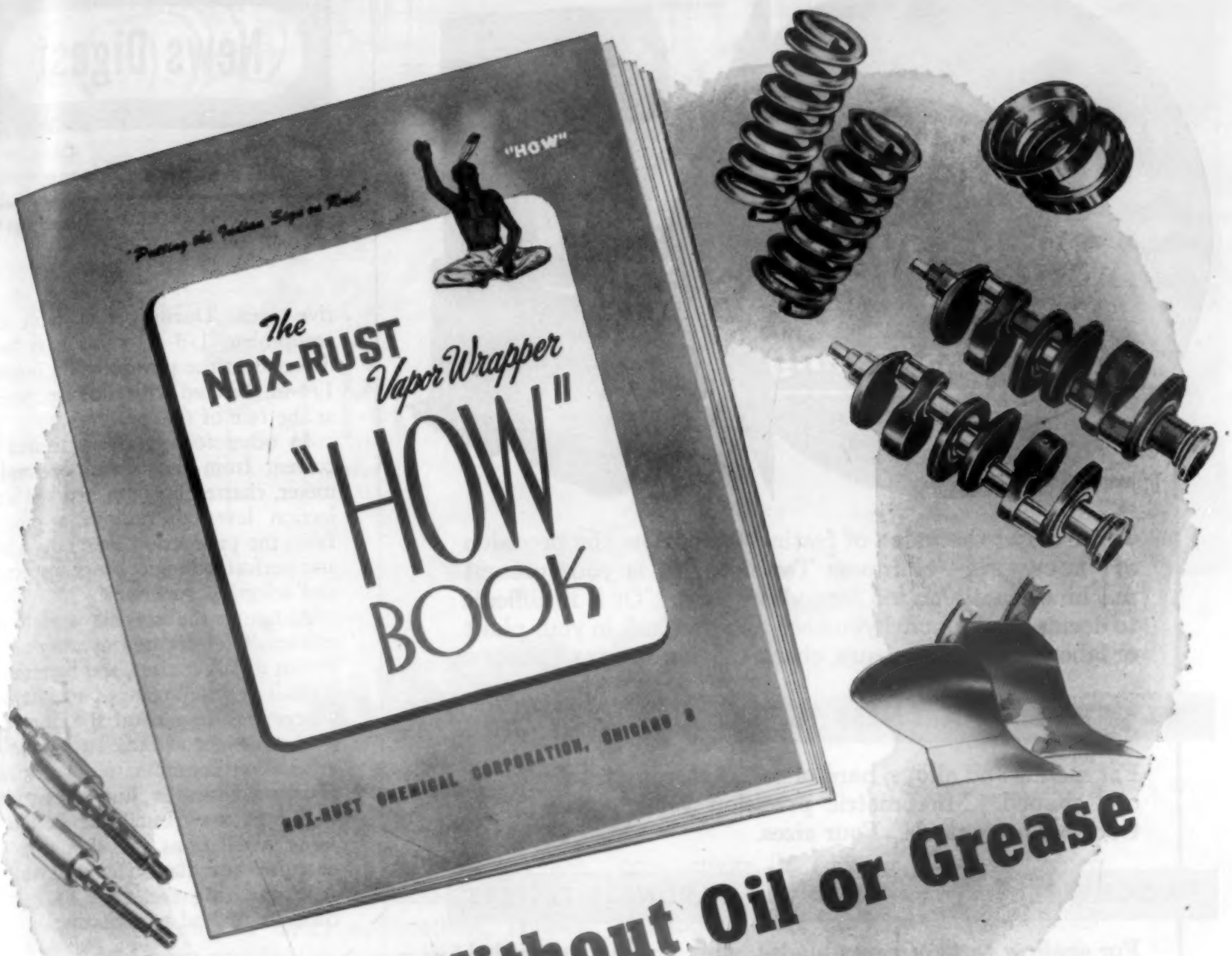
Channel Marking Machine

Developed by *M. E. Cunningham Co.*, 155 E. Carson St., Pittsburgh 19, the new CM-50 channel marking machine can be

In operation of this marking machine, a channel section is marked by pulling the handle from left to right.

used for stamping trade names, addresses or other identification on aluminum and other metal channel sections.

Although specifically designed for code identifying aluminum doors and windows, this equipment, according to the manufacturer, can also be produced for stamping small steel or aluminum channel sections of practically any shape.



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Do your beautifully machined parts reach your customers pitted with rust? Then send for the NOX-RUST representative. He will show you how other companies in your line have solved their problems. He will recommend products and methods of application that will certainly put the *Indian Sign on your rust problems* and probably save you money to boot. Remember . . . the NOX-RUST representative is a specialist from headquarters for rust preventives.

Have you heard of the *new way of packaging parts and machines* without the use of oil or grease-type rust preventive coatings? Do you know that now you can get metal parts from suppliers that are "factory-fresh" . . . sparkling clean and free of rust or grease? *Send for this important book* of case histories that will show you how others have eliminated slushing and de-greasing problems. No obligation. No cost. It's from Nox-Rust—Headquarters for Rust Preventive products.

Are you bidding on government orders that require preservative coatings? SEND FOR FOLDER LISTING FEDERAL RUST PREVENTIVE SPECIFICATIONS AND NOX-RUST PRODUCTS CONFORMING TO EACH.

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News Digest

Crystal Amplifies Energy

(*Continued from page 11*)

tive area. During tests with this equipment, 1/8-in. voids have been detected in the powder train inside a 1/4-in. dia cord with the fuse moving at the rate of 60 fpm.

In other tests, relays activated by current from the crystal operated a meter, charted a graph, worked a rejection lever to remove a product from the production line, rang a bell, and performed many other inspection and selection functions.

Although the crystals used to detect small defects are tiny, they can be grown to larger sizes, and batteries of crystals can be arranged to integrate a large area. In general, the laboratory models do not use the large spray of x-radiation common to conventional x-ray machines or fluoroscopes, but rather narrow pencil-like beams. In some installations, this should greatly decrease the radiation hazard, reducing or eliminating the need for special concrete or lead partitioning.

NPA Considering Support for New Iron Ore Reduction Method

The National Production Authority is reported to be considering a $6,000,000 loan for a new method of reducing iron ore without a blast furnace.

Although Julius Madaras, of Longview, Tex., inventor of the process, believes that it would relieve the critical steel shortage in months instead of years, several steel companies have already turned down his method on the grounds that it is another variation of the sponge iron process used during World War II.

Madaras offers the following explanation of his process:

By employing hydrogen made from natural gas or extracted from low-grade coal, the new process makes iron directly from iron ore. The ore is charged into a special type of pressure retort and raised to white heat in a few minutes. Then hydrogen gas is injected into the hot ore several

Product improvement and lower cost are two direct routes to increased sale-ability . . . and in many applications, Hussey Copper provides the answer on both counts.

Designing with this ageless metal assures both lifetime durability and lasting beauty . . . along with outstanding corrosion resistance and unmatched electrical and thermal conductivity. In addition, Hussey Copper offers the cost-cutting advantage of easy forming and fabrication, and rapid assembly by brazing, crimping, riveting, bolting, or laminating to other materials.

Adaptable Hussey Copper is available in shapes, sizes and gauges to meet every need.

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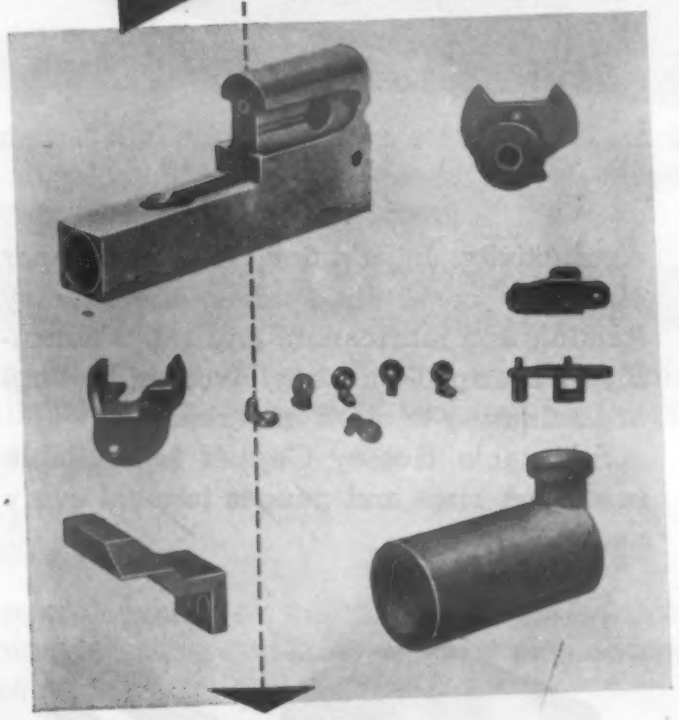
who knows what
TOMORROW'S needs will be

There is one
RIGHT WAY
to form these parts...



HITCHINER
PRECISION INVESTMENT CASTINGS

GET THIS BULLETIN FREE

It gives general, technical and design data.
Be ready with a complete knowledge of the possibilities — and the limitations — of precision investment castings when the need arises.

Answers to specific questions will be given gladly and without obligation if you send us complete details and prints.

HITCHINER MANUFACTURING COMPANY, INC.
MANCHESTER, NEW HAMPSHIRE
Representatives in all principal cities

News Digest

times, burning out the oxygen and forming steam. This leaves the hot, pure iron mixed with a small amount of gangue in a solid form.

The hot iron is then melted in an electric or open hearth furnace or in a cupola, where it separates from the gangue. In the process, the sulfur and most of the phosphorous are eliminated.

According to the inventor, the process should enable steel companies to increase their present production by 50% while effecting savings in fuel and labor.

New Synthetic Rubber Developed

Development of a new synthetic rubber, in some ways superior to natural rubber or other synthetic types, has been reported by three U. S. Dept. of Agriculture scientists.

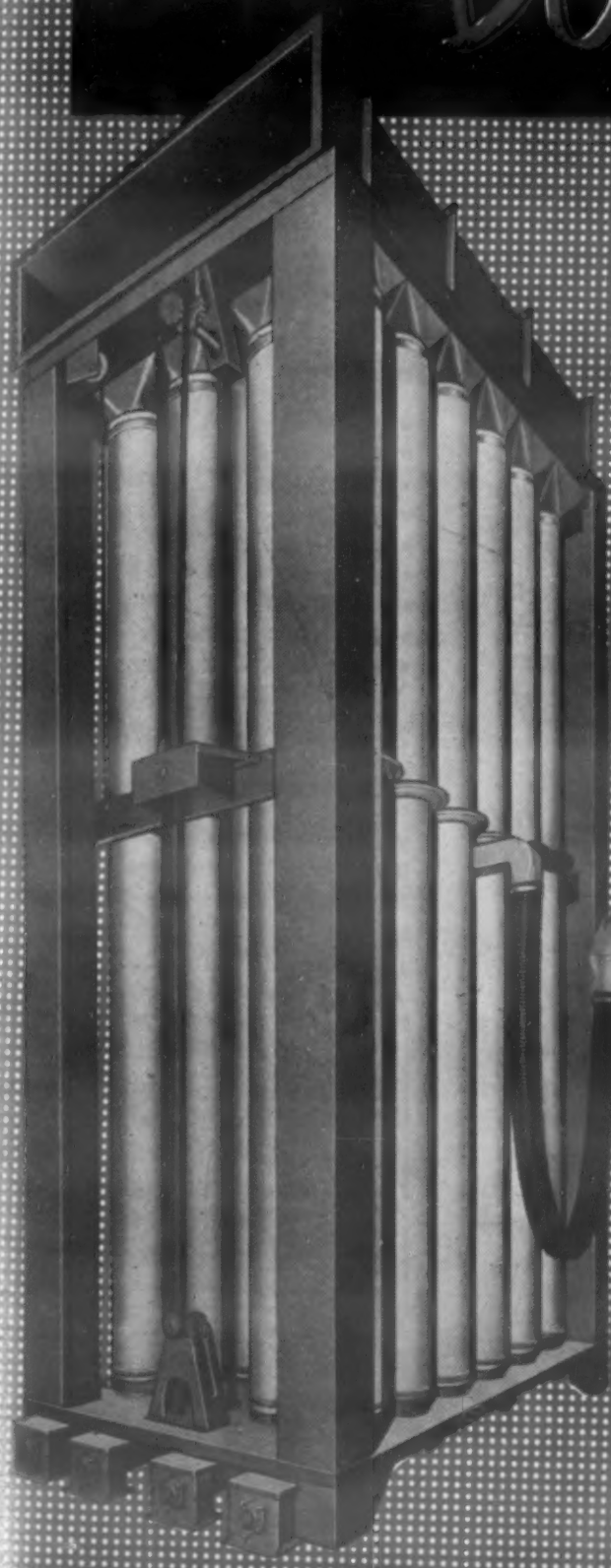
The new rubber, known as lactoprene BN, is expected to prove extremely useful for gaskets, seals for oils and other chemicals, and for linings for fuel tanks. Because it lacks tensile strength and abrasion resistance, the rubber is not suitable for automobile tires.

OTS Releases Report on Castings

Steel castings can be made radiographically sound without recourse to padding or chills if the distance from the perimeter of the riser to the edge of the plate is four and one-half times the casting distance, according to a report now available from the Office of Technical Services of the U. S. Dept. of Commerce. This information, based on tests of steels having 0.20 to 0.35% carbon and cast as plates with a width-to-thickness ratio of at least 3 to 1, resulted from a continuing study of basic foundry methods by the Naval Research Laboratory.

It was determined, according to the report, that three thermal zones develop during the solidification of

AMERICAN FELT captures RADIOACTIVE DUST



Type AC Dust Filter, (illustration shows unhoused unit) made by The Day Company, 810 3rd Ave. N. E., Minneapolis 13, Minn. The vertical tubes are the filter elements, and are made of American Felt. Manufactured under patent license from H. J. Hersey, Jr., who states "Felt is by far the best material I have found for reverse-jet filtering."

This Day Type AC Dust Filter uses American Felt as the filter medium, and offers 99.99% efficiency or better. Such efficiency is highly essential in what is the most important of all filtration jobs—recovery of dangerous radioactive dust. Limited maintenance and speedy service, minimum handling of collected dust are other safety features. The filter design is such that the felt is automatically cleared of dust by means of a constantly traveling reverse-jet. According to reports of actual tests conducted by a processor of radioactive material, the type of filter which best meets radioactive dust filtering requirements is based on the Hersey reverse-jet principle. In these tests, dust loads were from 0.07 to 32 grains per cubic foot, at air-to-cloth ratios of 16 to 27 cfm per sq. ft., and with pressure drops of 3.5 to 6.5 in. water gauge. Under these conditions, collection efficiencies ranged from 99.946% to 99.998%. Once again, American Felt demonstrates its unbeatable performance for filters. For technical information and illustrative samples, send for American Felt Company Data Sheet No. 15, "Felt and Filtration."

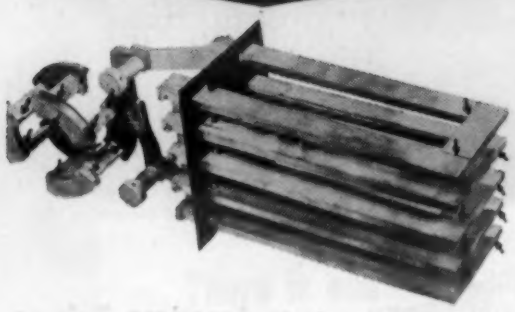
American Felt serves industry in many other important ways. It is produced in many different types, for such additional uses as: Sealing, Wicking, Wiping, Polishing, Vibration Isolation, Sound Absorption, Thermal Insulation, Shock Absorbing, Cushioning, Moistening, Padding, Packaging, Surfacing, Frictional. Tell us what applications are of interest to you, and full information will be sent.

American Felt Company

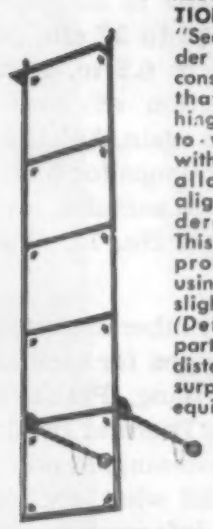
TRADE MARK

GENERAL OFFICES: 24 GLENVILLE ROAD, GLENVILLE, CONN. ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal.

FREE Le Tempsis EUTECTIC WELDING ALLOYS DATA FILE PROVES SAVINGS YOU CAN ENJOY IN PRODUCTION WELDING



EUTECROD 1800 DOES "IMPOSSIBLE" JOB WITH EASE. In the magnet charger shown above, 23 copper joints had to be welded *without distortion*, for the cumulative effect of even the slightest warpage per joint would ruin the job. This seemingly impossible metal-joining problem was easily solved with Eutec-Rod 1800—the fast-flowing, high conductivity, high strength "Eutectic Low Temperature Welding Alloy" that welds steel, copper, and nickel units that demand *distortion-free* elasticity. *(Write for complete data.)*



EUTECROD 16 STRENGTHENS RESCUE LADDER CONSTRUCTION. The Curtiss-Wright "Seahawk" collapsible ladder shown in the photo is constructed in cross-sections that swing together on hinges. Previous attempts to weld the ladder joints with conventional high-heat alloys resulted in misaligned structure that rendered the ladder unsafe. This unusual metal-joining problem was solved by using new EutecRod 16 and slight design modification. *(Details on request.)* The parts thus joined remained distortion-free and strong, surpassing the rigid Navy equipment requirements.

"EUTECTIC Low Temperature WELDING ALLOYS" are setting new standards for production and maintenance welding everywhere. Drawbacks of conventional brazing and fusion welding—such as distortion, warping, porosities, and weld failures — are minimized or completely eliminated when you use EUTECTIC's JOB PROVED hi-tensile low melting alloys.

WRITE FOR *FREE* PRODUCTION WELDING DATA FILE TODAY!

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EUTECTIC WELDING ALLOYS CORPORATION

Technical Information Section

40-40 172 STREET FLUSHING-NEW YORK, N.Y.

Independent Pioneer of the Welding Industry

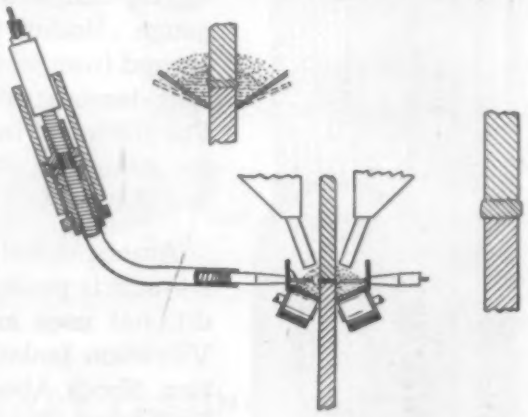
News Digest

plate castings: one adjacent to the riser, one at the casting edges, and an intermediate zone between the two—the latter essentially without a temperature gradient. Sound castings result when the intermediate zone is eliminated or at least reduced to a width of less than the casting thickness during the solidifying process.

Use of risers having diameters of three times the casting thickness was found satisfactory, but it appeared that the use of extra-large risers did not have a measureable effect on the distance that could be made sound.

Hidden Arc Welding Extended by New Process

Because of the development of a new process by The Lincoln Electric Co., Cleveland, automatic hidden arc welding can now be used to weld plate in any position from flat to vertical, as long as the joint is horizontal. In the past, automatic hidden arc welding could be used only for downhand welding.



This drawing from patent No. 2,529,812 indicates the reason for calling a new welding process "3 o'clock" welding. The horizontal seam in the vertical plate is being welded from both sides simultaneously.

Overcoming the difficulties of directing the electrode and retaining flux and molten metal in a joint not lying flat, the new process, referred to as "3 o'clock" welding, reduces the cost of welding and expands the possibilities for the application of hidden arc techniques.

Since the joints can be positioned horizontally, welds from both sides of

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138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000
250				

FREE —Tempil° "Basic Guide to Ferrous Metallurgy" — 16¼" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

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ENGELHARD also manufactures a line of wide-range thermocouples and accessories to meet your specific conditions of atmosphere and temperature. For complete information on either Repairs and Reclaiming or New Couples, fill out coupon below and mail today.

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News Digest

the joint can be made simultaneously (see cut). This reduces actual arc time on a given joint by approximately 50%, and results in lower direct labor costs. In addition, the positioning of each weld for downhand welding is eliminated, thereby reducing handling and set-up time.

Other savings are achieved because of the smaller sizes of electrode wire used. In the place of a 7/32-in. dia electrode for downhand welding, for example, a 3/32- or 1/8-in. dia electrode can be used in the "3 o'clock" position. This, in turn, means that lower currents are used, less electrode required, welds of reduced cross-sectional area made, and less metal wasted in unnecessary build-up. Welds can be made in either straight seams or following an irregular contour. Furthermore, tendency to burn through is reduced and back-up strips can be eliminated where two arcs on opposite sides of the work are used.

Open Hearth Slag Used as Blast Furnace Charge

Much of the open hearth slag formerly dumped onto wasteland in the vicinity of steel plants is now prepared for use as part of the flux burden of blast furnaces, according to the American Iron and Steel Institute. This use of the open hearth slag not only decreases the amount of new limestone used, but recovers valuable quantities of iron and manganese.

Slag that is to be used in the blast furnace is tapped into ladles which are held 12 to 18 hr to insure complete solidification. Then the ladles are dumped over a heavy screen having openings about a foot square. The brittle slag fractures, and much of it passes through the screen unaided.

Properly sized, the material goes to the blast furnace to replace approximately 10% of the flux burdens. Slag emerging from the blast furnace contains only about one-half of 1% iron and less than 2% manganese—indicating that appreciable amounts of

FREE Low Temperature EUTECTIC WELDING ALLOYS DATA FILE PROVES SAVINGS YOU CAN ENJOY IN MAINTENANCE WELDING

SALVAGE WELDING TIME CUT MORE THAN 90% WITH NEW Low Temperature EUTECTIC WELDING ALLOYS

When a leading research institute's tensile testing machine was overloaded, the top snapped completely off the two side members. At first, the old-fashioned conventional high heat fusion methods were tried. The entire operation—pre-heat, slow cool, etc.—consumed 48 hours in all; and, on the first day after its repair, the casting cracked wide open again, through and alongside the welding area. It seemed as though the entire casting would have to be scrapped. Before taking this costly step, Eutectic was consulted . . .

The damage was repaired permanently with EUTECTIC's BIG TEAM — CutTrode + EutecTrode 24, for cast iron. CutTrode—a new special metallic-arc oxygen-less cutting electrode first beveled the breaks, in preparation for welding. Sufficient residual heat remained from the use of CutTrode to weld the entire job without any further pre-heat. The breaks were first tack welded; then stringer beads were deposited with new EutecTrode 24. The entire job—permanently welded—was accomplished in only 4 hours—*1/12 THE ORDINARY WELDING TIME!* (Complete details and photos of this job available on request.)

"EUTECTIC Low Temperature WELDING ALLOYS" are setting new standards for production and maintenance welding everywhere. Drawbacks of conventional brazing and fusion welding—such as distortion, warping, porosities, and weld failures — are minimized or completely eliminated when you use EUTECTIC's JOB PROVED hi-tensile low melting alloys.

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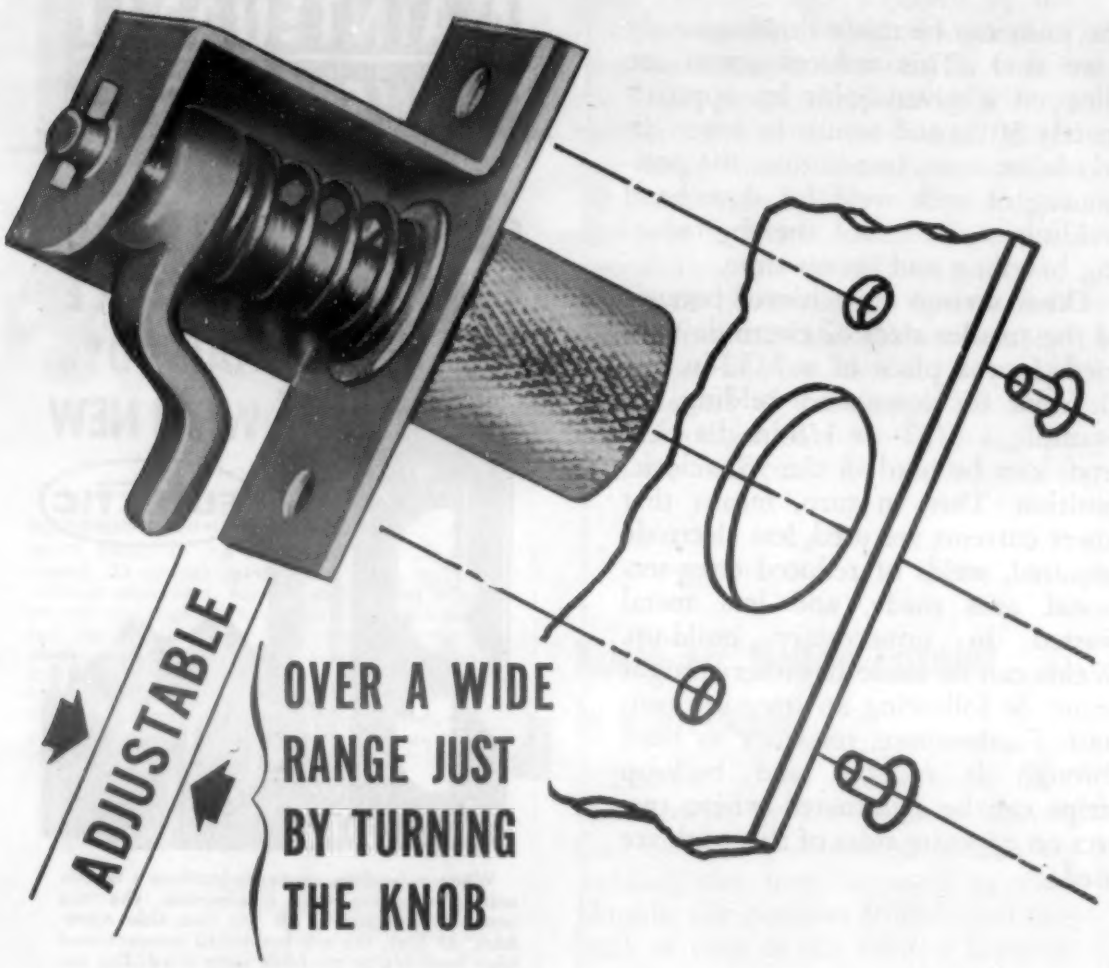
ONE door fastener fits MANY panel thicknesses



SOUTHCO quarter-turn fasteners offer double advantages:

1. **quick adjustment so that panels of various thicknesses are *always* held tight.**
2. **installation simplicity, including elimination of striker plates to save time, lower costs.**

Available with knurled knob or flush, key-operated heads.

Send for complete information. SOUTHCO Div., South Chester Corporation, 1404 Finance Bldg., Philadelphia 2, Pa.

Baldwin-Tate-Emery Testing Machines are SOUTHCO Fastener equipped. Activating knobs serve also as handles for lifting and holding door.

SOUTHCO®

DOOR FASTENERS

News Digest

both of the elements have been recovered.

Unfortunately, however, the amount of open hearth slag used in the blast furnace is limited by its phosphorous content, since the blast furnace process does not remove phosphorous from iron.

New Tetraethyl Process Announced

A new continuous process for the manufacture of tetraethyl lead has been announced by E. I. du Pont de Nemours & Co., Inc. Construction has already started on the first continuous production unit, which will have a capacity of approximately 50,000,000 lb of tetraethyl lead annually. The unit will be located at the company's Chamber Works at Deepwater Point, N. J., and is expected to be in full production by January, 1952.

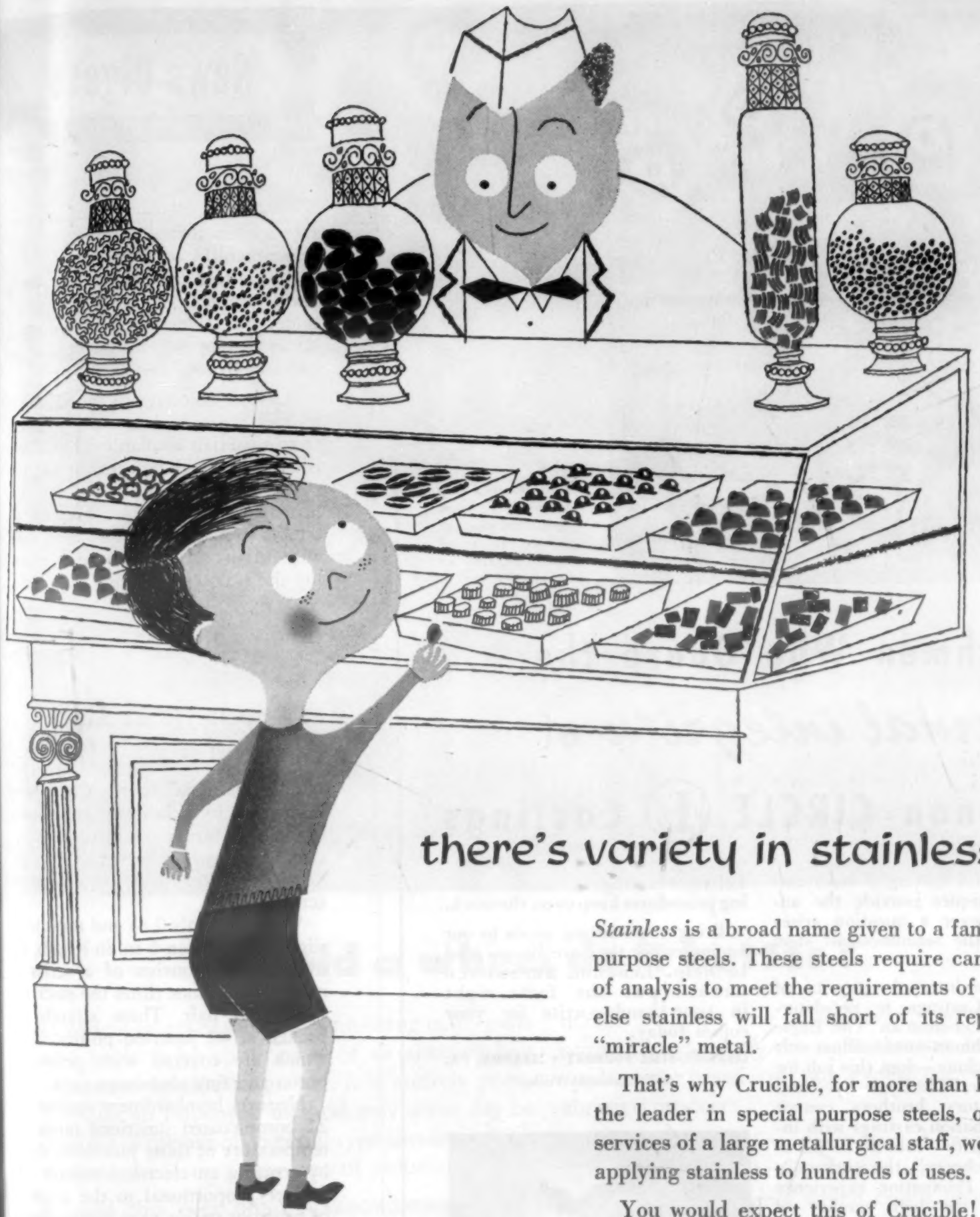
Tetraethyl lead has until now been made in batches. The new process, in addition to increasing productive output, eliminates the need for equipment made of special steel alloys which are essential in the batch process.

Industry Attempts to Produce "Tinless" Tin Cans

A scientific research project, known as "Operation Survival," has been instituted by the American Can Co. to make the U. S. canning industry less dependent on tin for its operations.

Findings are already reported to have reached the stage where they will materially lessen the impact of the recent orders, reducing civilian use of tin by 20%. The following progress has been reported to date:

1. In pilot-line operations, cans made of tinless steel and low tin-bearing solder have been made at speeds comparable to that at which tinplate cans are made.
2. Cans have been made with tin-



there's variety in stainless, too!

Stainless is a broad name given to a family of special purpose steels. These steels require careful selection of analysis to meet the requirements of the user — or else stainless will fall short of its reputation as a "miracle" metal.

That's why Crucible, for more than half a century the leader in special purpose steels, offers you the services of a large metallurgical staff, well-schooled in applying stainless to hundreds of uses.

You would expect this of Crucible! For Crucible was one of the first to build — from the ground up — a completely integrated mill to roll stainless exclusively. If yours is a stainless steel application, call on our unequalled background of experience. CRUCIBLE STEEL COMPANY OF AMERICA, Oliver Building, Pittsburgh, Pennsylvania.

CRUCIBLE first name in special purpose steels

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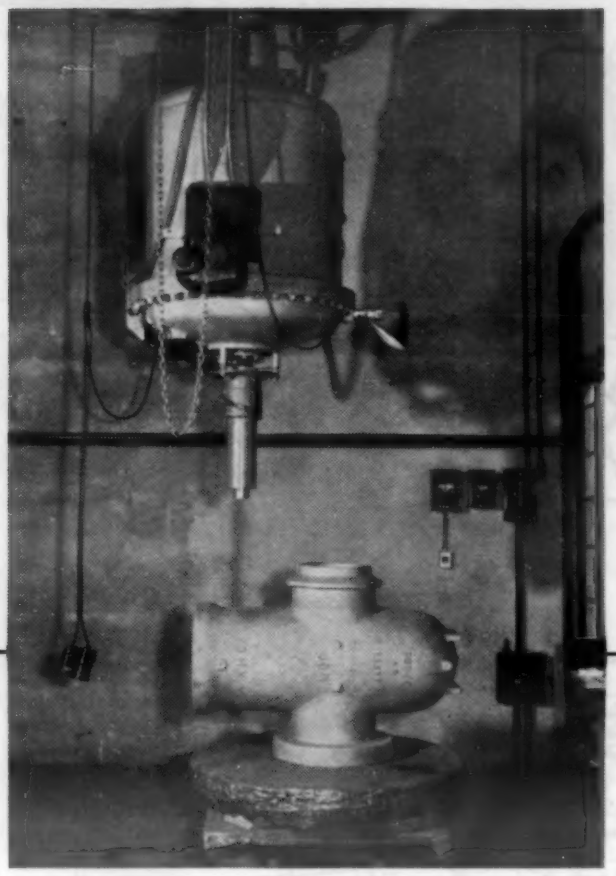
STAINLESS • HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE STEELS



Million-volt X-Ray Machine . . . an important part of the well-equipped Laboratories at Lebanon.

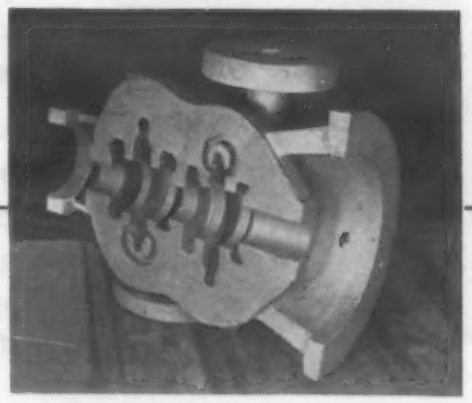
Watchmen Who Guard the *internal integrity* of Lebanon CIRCLE (L) Castings

MODERN testing devices and techniques provide the answer whenever a question arises regarding the soundness of steel castings.

Now the internal integrity of Lebanon Castings is pre-determined. At Lebanon an "Old Eagle Eye" watchman—our million-volt X-Ray machine—does this job for us. However, "Old Eagle Eye" and his laboratory brothers cannot *produce* Lebanon castings with internal integrity—that is the job of other "watchmen", the workers in our plant. Production experience establishes the high quality of Lebanon castings . . . modern testing procedures keep us on the mark.

Bring your casting needs to our engineers, for they are always glad to help. Lebanon REFERENCE CHARTS put the facts right in your hands—write for your copies today.

LEBANON STEEL FOUNDRY • LEBANON, PA.
"In the Lebanon Valley"



This Pump Casing is a typical example of a Lebanon casting that will stand up in service because it stood up on test.

LEBANON ALLOY AND STEEL Castings

CIRCLE L

News Digest

free solders that give every promise of adaptability to universal use.

3. Tin-free cans in which a special plastic cement is used instead of solder for side-seams are currently under test by several packers of oil and anti-freeze.

Another objective of the project is to find organic plate coatings made from materials available on this continent which will be equal or superior to those now made from tin. The principal difficulty in present attempts to make cans from steel sheet with no tin coating has been in soldering the side seam of the can.

Watchmakers Produce Atomic Thermometer

Elgin National Watch Co. has revealed that its technicians are helping to manufacture a "neutron-sensitive thermopile" which serves as a watchdog over neutron levels in atomic reactors.

Weighing only 2 oz and measuring slightly more than 6 in. in length, the thermometer consists of a series of metal strands four times the thickness of human hair. These strands are broken at 42 junction points, 21 of which are covered with pellets of boron and tiny aluminum caps.

Neutron bombardment against the 21 boron-coated junctions raises the temperature of those junctions, thereby creating an electrical voltage difference proportional to the quantity of neutrons striking the thermometer.

The instrument was developed by the Atomic Energy Commission and is being marketed by Nuclear Instrument and Chemical Corp. of Chicago.

•

Substitutes for Scarce Materials

See "Engineering File Facts," p. 107, for a comprehensive table on Alternate and Substitute Materials for Electrical Equipment and Parts.

Could a wheel do it better?

A widely accepted method of finishing many parts and tools is by application of an abrasive belt of certain specifications. Yet, it is entirely possible that an improved method may some day be devised—the use of a special-type abrasive wheel, for instance... on a new type of polishing wheel.

Should this ever occur, CARBORUNDUM would undoubtedly be among the first to produce the right wheel. But, *even more important,* we would be fully prepared to explain the pros and cons of both methods. Because only CARBORUNDUM makes a *complete* line of abrasives...we can recommend *impartially* the right abrasive for every application based on our experience with all abrasive products.

Perhaps the past few years have brought new developments in abrasives of which you are not aware—developments which could provide increased production, efficiency and economy for you. Your CARBORUNDUM representative will gladly give you impartial technical advice on proper application to your processing.

Only CARBORUNDUM

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makes ALL abrasives to give you the proper ONE

"Carborundum" is a registered trademark which indicates manufacture by The Carborundum Company, Niagara Falls, N. Y.

Finer grain structure — higher heat resistance — increased tensile strength — only a few of the advantages gained when master alloys of titanium and zirconium are added to your metal products. Now produced commercially by Metal Hydrides Incorporated, titanium and zirconium are available as powders, sintered granules, fused lumps or hydride powders.

In addition to these, Metal Hydrides also produces binary master alloys of Zr-Cu, Cr-Ni, Zr-Ni, Zr-Mg. All are available in a wide range of composition as either powder (325 mesh) fused lumps, or sintered granules.

Can these amazing new metals help you? Find out by writing Metal Hydrides Incorporated today for complete details.

✓ Check these unusual advantages of MH Metal Hydrides.

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- ✓ **Fortify and refine grain structures**
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- ✓ **Zirconium hydride provides gettering — safest for the removal of gas from vacuum tubes**
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News Digest

New Paint Changes Color as Temperature Rises

Studies of cooling processes for air-cooled internal combustion engines at Socony-Vacuum Oil Co., Inc. have been simplified by the use of a new type of paint which changes color as specific temperature levels are reached.

Formulated to provide 15 basic shades for original application, the paint assists in determining proper locations for thermocouples to measure internal heat while an engine is in operation. Before the development of the paint, incorrectly placed thermocouples often distorted air currents around the test engine sufficiently to affect the accuracy of the measurements.

Some of the 15 basic paints are capable of six complete changes in color as the temperatures rise. One of these, violet blue at room temperature, becomes bright green at 311 F, olive green at 446 F, dark gray at 545 F, light gray at 554 F, light brown at 572 F, and buff at 644 F. Another paint, basically red, becomes brown-gray at 770 F, yellow at 914 F, orange at 1067 F, and green at 1472 F.

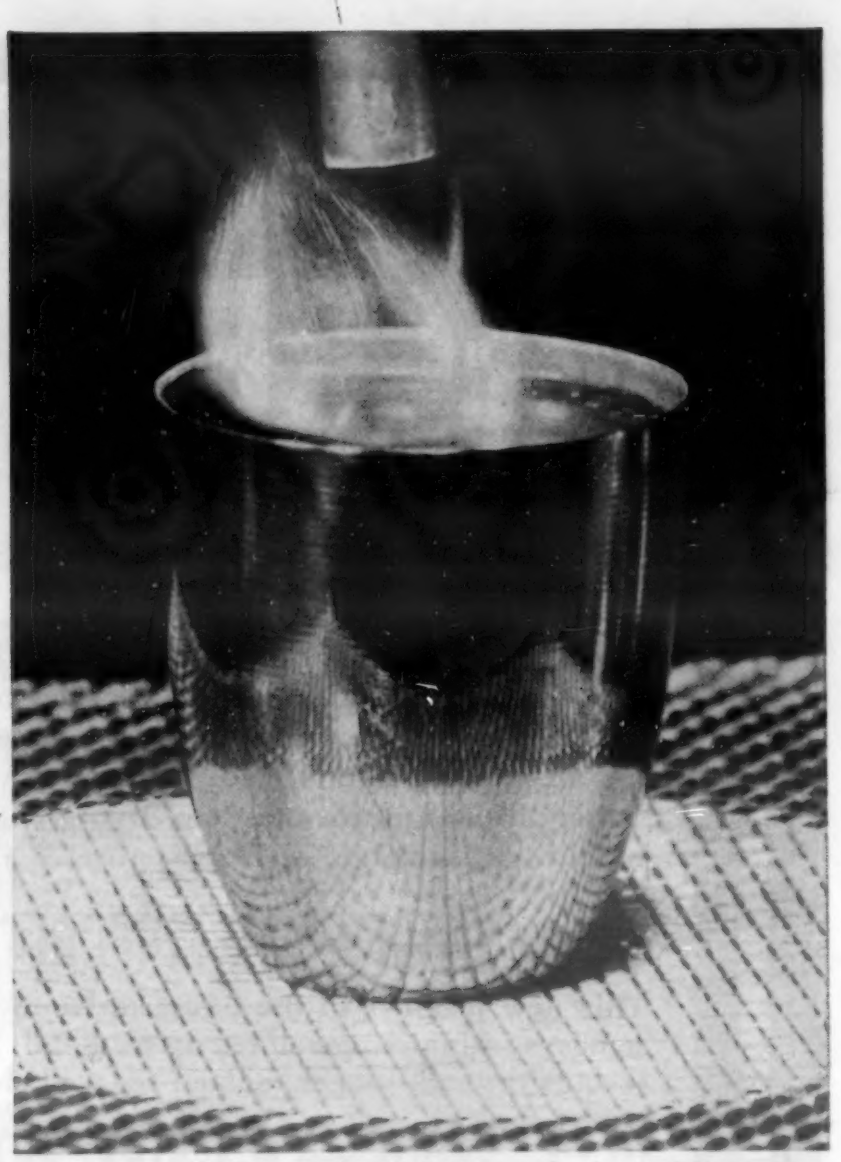
During actual tests, engines covered with the paint develop color bars which show a marked similarity to isobars on a weather map.

News of Engineers

Robert L. Pettibone, research metallurgist, was promoted to the position of chief metallurgical engineer of the Sintercast Corp. of America.

American Cyanamid Co. has elected *Raymond C. Gaugler,* executive vice president and a director, to the position of president of the company, filling the vacancy caused by the sudden death of *William B. Bell.* At the same time, it was announced that *Dr. David F. Smith* and *Roland A. Sherwood* have joined the company as director of development and assistant to the general manager, respectively. Dr. Smith

When WATER BURNS



This water is literally burning under the jet of Fluorine gas; hydrogen is being snatched from H_2O to form HF (hydrofluoric acid). The crucible is unharmed . . . it is pure Nickel.

Courtesy Pennsylvania Salt Mfg. Co.

When water burns – when glass dissolves – when stone crumbles – when asbestos, rubber, steel go up in flame . . . watch out! Anything that causes such destruction is hard to handle.

Hard-to-handle is a mild description for this element, Fluorine. It is called nature's supreme terrorist. And taming Fluorine's attack was one of the greatest corrosive problems ever.

Numerous materials – usually reliable for anti-corrosion applications – were tried. Most of them were chewed up in a flash. Some seemed to work, at first. Then, with a boost in temperature, or increase in pressure, or maybe a trace of moisture or hydrogen, or even air – the whole business would disintegrate in a flare.

Finally Nickel was tried. There was the answer. You find Nickel and INCO Nickel Alloys on the job now; in producing pure Fluorine by electrolysis, in compressing and storing it, and in processing it into new products.

Maybe Nickel or an INCO Nickel Alloy could be the solution for your corrosion problems, too. If you are having trouble with corrosion, write for our corrosive data worksheet . . . you'll find it a big aid in explaining your problem. See if INCO Corrosion Engineers don't have the answer for you.

For the present, there are not enough Nickel and INCO Nickel Alloys to meet the abnormal civilian demand in addition to DO's and military applications. But we are eager to aid in the development of new products or processes . . . for quicker action when normal times are here again.

EMBLEM OF SERVICE INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street, New York 5, N. Y.

CAST SPECIAL SHAPES QUICKLY . . . EASILY

. . . with these

FIRECRETE

Castable Refractories

Check the job to be done and you will find a Firecrete* product that will do it well. For special refractory shapes or linings it's simply mix and cast. The new shape or lining air-hardens and is ready for service within 24 hours. Other advantages include—no drying shrinkage, negligible firing shrinkage, high resistance to spalling.

For use up to 3000F — 3X FIRECRETE

This new member of the Firecrete family effectively withstands soaking temperatures up to a full 3000F. Provides savings through longer life and reduced shutdowns.

For use up to 2800F — H-T FIRECRETE

A high heat-duty refractory composed of an exceptionally heat-resistant base. Specially developed for service between 2400F and 2800F.

For use up to 2400F — STANDARD FIRECRETE

The most generally applicable type of Firecrete. Finely ground, permitting casting of shapes or linings as thin as 1½".

For use up to 2400F — L-W FIRECRETE

A lightweight insulating refractory concrete with unusually low thermal conductivity, low heat storage capacity and high resistance to spalling.

The above Firecrete materials can be used in combination where varying temperature and service conditions are encountered.

For patching and gunning, use 3X BLAZECRETE. For temperatures to 3000F. It has exceptional adherence qualities, can be flipped into place with a trowel without ramming or tamping.

For further information, write to Johns-Manville, Box 290, New York 16, N. Y.

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FIRECRETE

"The Standard in Castables"

News Digest

recently was director of research, develop ment and control of Johnson and Johnso and director and vice president of the Re search Foundation. Mr. Sherwood formerl served as assistant to the president of th American Locomotive Co.

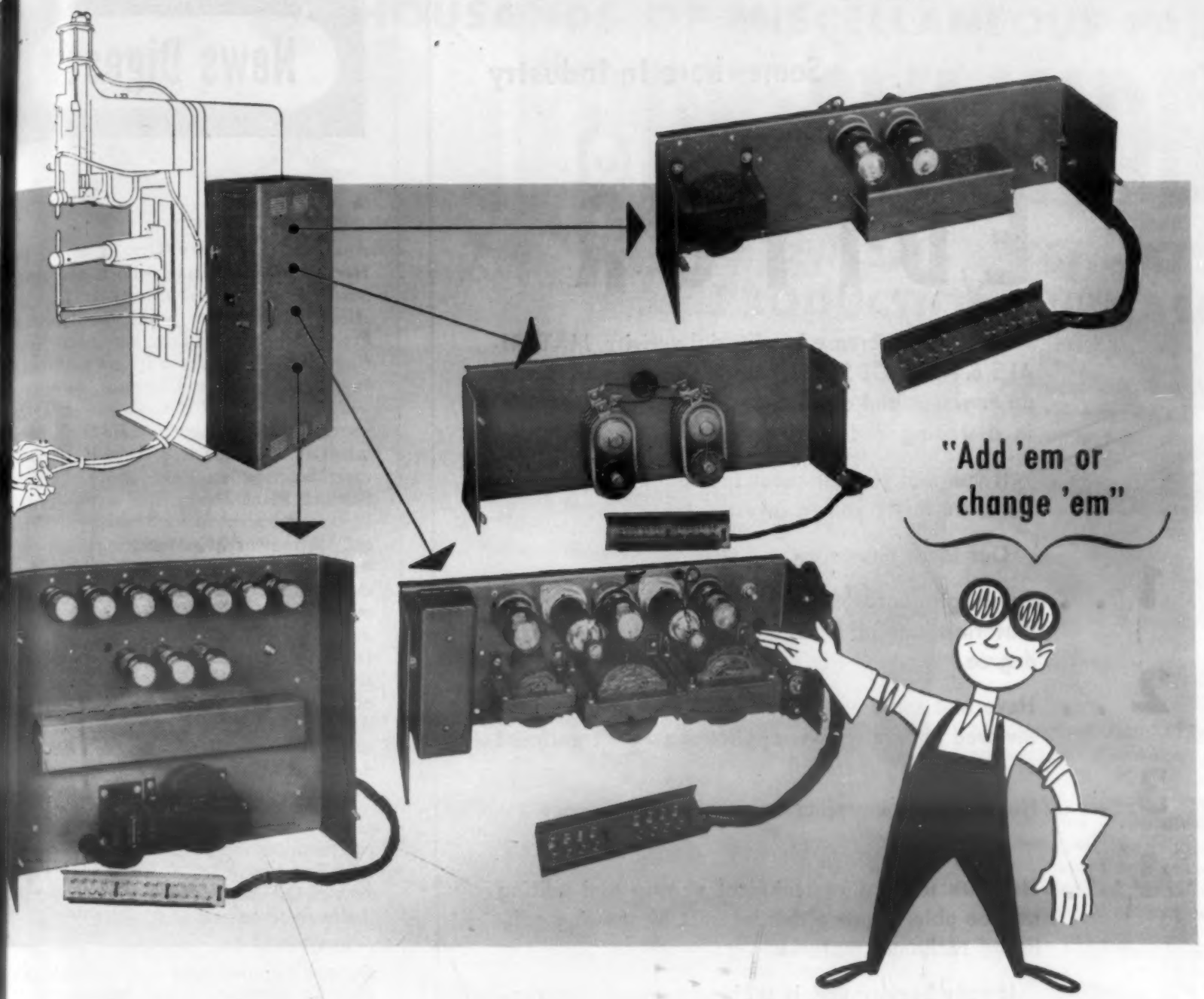
Victor F. Stine and *Lloyd L. Stauffe* have been elected directors of the Pangbor Corp. Mr. Stine, vice president in charge o sales, also assumes the duties of vice presi dent in charge of sales and engineering, an Mr. Stauffer, secretary and assistant treas urer, is now secretary and treasurer, an takes charge of production. Executive vice president *P. J. Potter* is retiring from hi more active duties but will continue to serve Pangborn as director and vice president.

The United States Steel Co. has announced the promotion of *L. V. Johnson*, assistant chief engineer, to the position of chief engineer. He assumes the duties of *John L. Young*, who was recently elected vice president-chief engineer of the newly-formed United States Steel Co. *John H. Elliott*, assistant general manager of operations, was named general manager of manufacturing. *William C. Oberg*, general manager of operations, assumes the position of manufacturing consultant. *Robert C. Tyson* was elected a vice president, and will continue his duties as comptroller. And finally, *John G. Munson* has retired from the post of vice president—raw materials of the United States Steel Corp. of Delware, now merged into the United States Steel Co. For a time Mr. Munson will serve the company in an advisory capacity.

The election of *Paul M. Arnall*, general manager, as president of The Lunkenheimer Co. has been announced. He succeeds *Frank P. Rhame*, who has retired from this position, but will continue to serve as a director and in an advisory and consulting capacity.

Frank Hallberg has joined the Ross Operating Valve Co. as chief engineer. He previously was connected with the Clinton Machine Co.

General Electric Co. has announced a number of changes in its various divisions. *Ralph J. Cordiner*, executive vice president and a director of the company, was elected president, to succeed *Charles E. Wilson*, who resigned to become chairman of the new Defense Mobilization Board. Mr. Cordiner has been associated with G.E. for 24 years, and has served as manager of five of the company's departments during that period. In the Chemistry Divs. of G.E.'s Research Laboratory, Dr. *A. L. Marshall* became manager, *Anthony J. Nerad* assistant manager, and Dr. *Arthur E. Newkirk* assistant to the manager. Dr. *William E. Cass* was named head of the Organic Chemistry Div., with Dr. *John R. Elliott* as associate head. The



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Westinghouse Welding Controls keep pace with such changes. When a new welding technique is required, synchronous or nonsynchronous, seam or spot—interchange components to meet the need.

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Your Westinghouse representative will show you in detail how you can increase the life-span of your resistance welding control. Ask him for a copy of Booklet B-4309 or write direct to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-27007

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There Is A Potential

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Our ideal man must:

1 . . Be a graduate engineer, preferably holding a materials, metallurgical or chemical engineering degree.

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3 . . Have design or project engineering experience.

4 . . Have an interest in technical writing and editing and be able to prove this interest by showing published technical material.

If your background is such as to meet these requirements, please send complete details in a letter. Your letter should also include marital and military status, salary requirements and some evidence of your writing ability.

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is one of the fastest growing technical magazines now being published and is serving a field—materials engineering—which is one of the most important in American industry. As an editor on MATERIALS & METHODS you would contact leaders in industry for information on the proper use of engineering materials and then pass this helpful knowledge on to our more than 18,000 readers.

Address your communication to:

T. C. Du Mond, Editor
MATERIALS & METHODS
330 West 42nd Street
New York 18, N. Y.

News Digest

Analytical Chemistry Div. is under Dr. *Herman A. Liebhafsky*, who is also acting head of the Physical Chemistry Div. Dr. *Albert E. Schubert* heads the Chemical Process Engineering Div., while Mr. Nerad continues to head the work on mechanical investigations. The Chemical Dept. has named *Robert J. Baumann* marketing research section manager, while the Chemicals Div. has acquired *John L. Galt* as manufacturing engineer of its Phenolic Products Plant. *Henry A. Vaughn*, formerly superintendent of the Specialty & Standard Instrument Manufacturing Divs., has succeeded *Herbert L. Ross* as manager of manufacturing of G.E.'s Meter & Instrument Divs. *Emil R. Schaeffer* was promoted from assistant to manager of manufacturing of the Switchgear Div. And finally, *Ab Martin* was appointed manager of the Fort Wayne (Ind.) Works of the Apparatus Dept., to succeed *C. H. Matson*, who becomes manufacturing consultant of the Small Apparatus Div. Staff.

The Osborn Manufacturing Co. elected as its president *Norman F. Smith*, formerly vice president and general manager. He succeeds *Franklin G. Smith*, founder and president of Osborn since 1892, who becomes chairman of the board.

W. I. Tebo was appointed Washington engineering consultant and technical advisor for Detrex Corp., with headquarters in Washington, D. C.

Lester Engineering Co. has delegated *David White*, vice president, to the position of president of the company. *David Sloane*, formerly assistant to Mr. Lester, assumes the office of vice president in charge of engineering development.

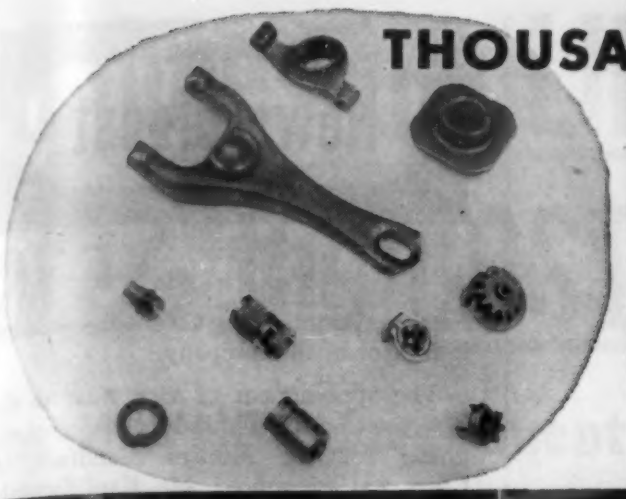
John C. Redmond, formerly research director, has been elected vice president in charge of metallurgical development for Kennametal, Inc. At the same time, *Alex G. McKenna* was made executive vice president and *Richard J. Flickinger* was named assistant secretary.

The National Research Council has appointed Dr. *Robert F. Mehl* chairman of the Metallurgical Advisory Board of the Council. Dr. Mehl has been granted a temporary leave of absence from Carnegie Institute of Technology, where he is director of the Metals Research Laboratory and head of the Dept. of Metallurgical Engineering.

Frank W. Jarvis was elected to the presidency of the Diamond Magnesium Co., a subsidiary of Diamond Alkali Co.

Atlantic Steel Co. has named *Paul A. Duke* product engineer, after being connected with Atlantic Steel since 1948 as Atlantic representative for their Warehouse Div.

Oscar S. Straus, treasurer of American

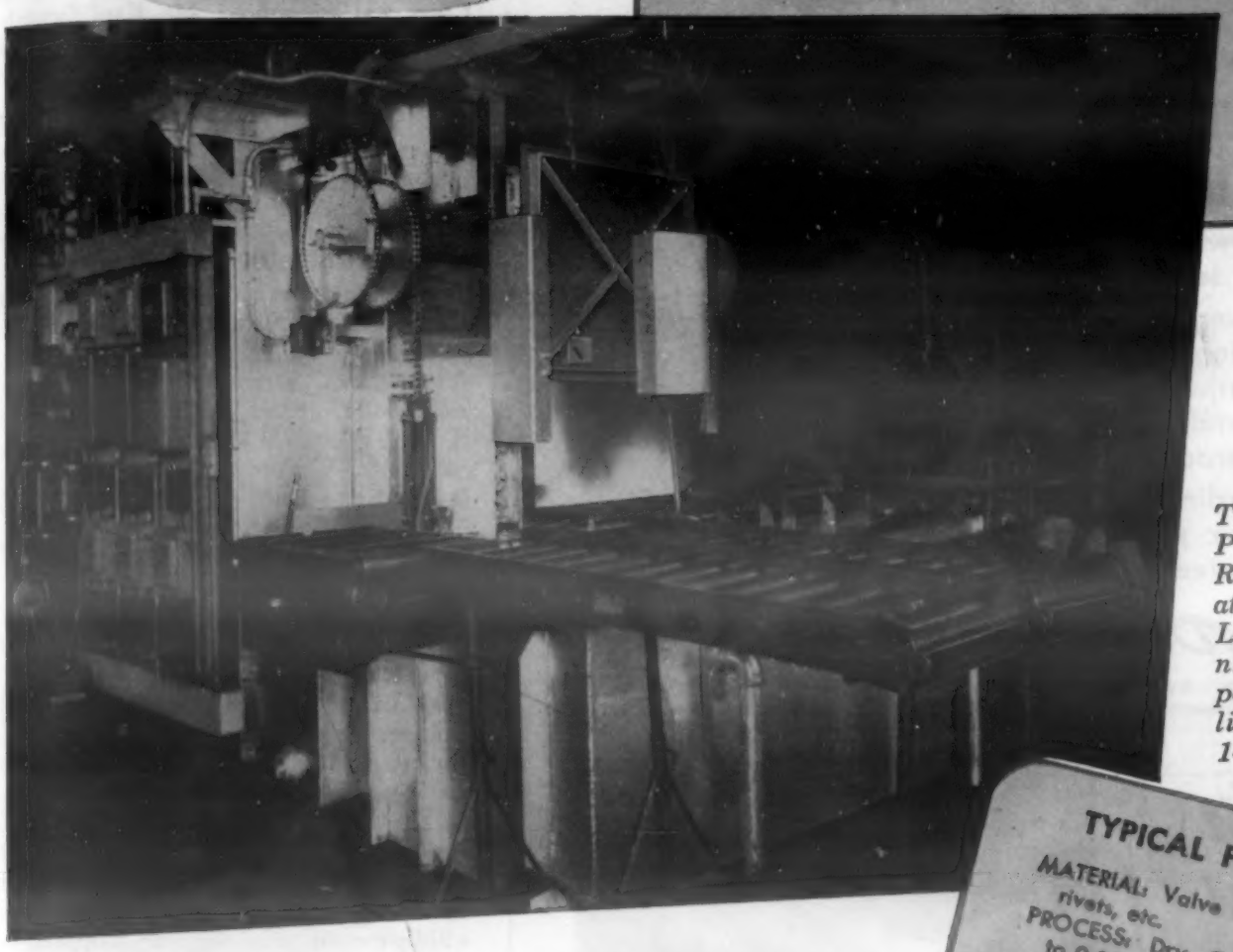


THOUSANDS OF MISCELLANEOUS PARTS

*DRY CYANIDED

IN THIS 'Surface' BATCH-TYPE HIGH-PRODUCTION FURNACE

*'Surface' RX Gas Atmosphere enriched with natural and ammonia gas.



This 'Surface' Batch-Type, High Production Furnace features Radiant Tube Heating, built-in atmosphere generator (optional), Loading and Unloading mechanism, integrally built tank equipped with lowerator mechanism for liquid quenching. Occupies only 144 square feet of floor space.

TYPICAL PERFORMANCE DATA:

MATERIAL: Valve lifters; pinion gears; stampings; rivets, etc.
PROCESS: Dry Cyaniding. Case depth 0.002" to 0.020".
HARDNESS: File hard.
CYCLE: Loaded trays moved into vestibule. Trays move readily in and out of furnace on roller hearth. Lowerator mechanism provides convenient oil quenching from atmosphere-purged vestibule.
TOTAL TIME: 1 hr. to 2 hrs.—12 min. varying with parts and case depth required.
NET LOADS: Up to 800 lbs. for these parts.

24-HOUR PER DAY OPERATION ESTABLISHES RECORD PRODUCTION FOR INDUSTRIAL HEAT TREATING COMPANY, TOLEDO, OHIO

In a commercial heat treating shop the furnace equipment must be flexible to meet the varied demands of batch heat treatment and provide mass production economy. *This 'Surface' Batch-Type High Production Furnace installation meets all these requirements for Dry (Gas) Cyaniding, Gas Carburizing, Carbon Restoration (Skin Recovery), Homogeneous Carburization, Clean Hardening and for General Heat Treating.*

This 'Surface' furnace requires a minimum investment for each pound of capacity. Light case dry (gas) cyaniding can be done for less than one-half cent per pound of work, exclusive of burden and fixed charges. Investigate its cost reducing possibilities for your plant—too!

WRITE FOR BULLETIN SC-145
"Dry Gas Cyaniding in 'Surface' Continuous and Batch-Type Furnaces"
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FOREIGN AFFILIATES: Stein & Roubaix, Paris — British Furnaces, Ltd., Chesterfield

'Surface' **INDUSTRIAL FURNACES**

FOR: Gas Carburizing and Carbon Restoration (Skin Recovery), Homogeneous Carburization, Clean and Bright Atmosphere Hardening, Bright Gas-Normalizing and Annealing, Dry (Gas) Cyaniding, Bright Super-Fast Gas Quenching, Atmosphere Malleableizing and Atmosphere Forging. Gas Atmosphere Generators.

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Saved Prime Contractors Vital Time in SPINNING, FABRICATING, And ASSEMBLING Complete Units

PROBLEM: — Efficient, low-cost production of exhaust gas boiler for distilling sea water.

SOLUTION: — Turning over spinning, piercing, welding, assembling and testing to PHOENIXSPUN technicians — resulting in substantial reduction in tooling costs, lower production time, and prompt delivery of assembled units to prime contractor, Cleaver-Brooks Co.

INQUIRE regarding Phoenixspun Service applied to **your** production needs. Your prints will receive our prompt attention.

Metal Spinning Division PHOENIX PRODUCTS CO.

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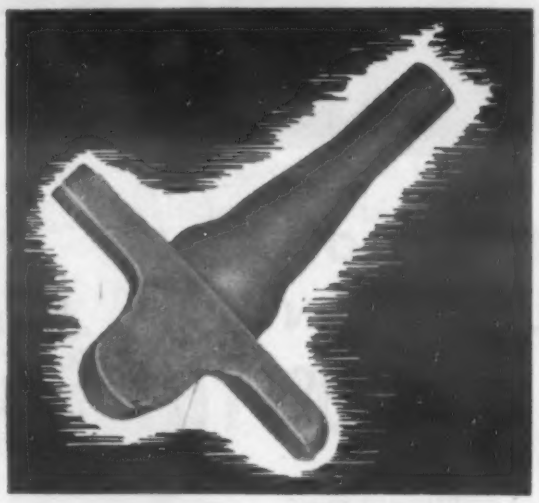
Better Forgings AT LOWER COST WITH Ajax-Northrup Induction Heating



Single-stroke extrusion of these axle spindles, made possible by scale-free Ajax-Northrup induction heat, provides a continuous stream of 600 forgings per hour for a leading automobile manufacturer.

Pit-free surfaces and superior fibre flow make these extruded forgings better . . . fatigue resistance is increased by 17% over hammered forgings. And costs are lowered, because 16 men do the work of 46 . . . virtual elimination of scale and flash saves up to *ten tons* of SAE 1532 bar stock per day . . . floor space requirements are reduced by 80% . . . one single-cavity extrusion die takes the place of two three-cavity hammer dies.

Find out how fast, economical Ajax-Northrup heaters can help *you* to convert to better, more economical forging methods. Send for our technical bulletins today.

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HEATING & MELTING

129

News Digest

Smelting and Refining Co., has been elected a director of the company.

The appointment of *Ben Kaul* to the new position of technical development engineer for the Mullins Manufacturing Corp. was announced. Mr. Kaul formerly served as chief tool and die engineer for the firm's Warren Div.

The Budd Co. has promoted both *Ernest R. Schmidt* and *Raymond F. Littley* to the position of vice president. Mr. Schmidt, plant manager of the Hunting Park Plant, succeeds *Warren H. Farr,* who resigned as vice president in charge of manufacturing, but will continue to serve the company as a member of the board of directors. Mr. Littley was recently sales manager of Budd's Automotive Div. It was also announced that *Albert Walton* was named general manager of manufacturing. *D. A. Coyle* succeeds Mr. Walton as plant manager of Budd's Charlevoix Plant.

Donald C. Peters, a professional engineer, was elected president of the Mellon-Stuart Co.

Koppers Co., Inc. has announced several appointments in its various divisions: *Edward Salner* becomes manager of the Precipitator Dept. of the Metal Products Div. He had been assistant manager of the department. In the Engineering & Construction Div., three vice presidents were added. They are *Gordon Fox, Harry Naismith* and *W. B. Clemmitt,* all of whom have been affiliated with Freyn Engineering Co., a wholly-owned subsidiary of Koppers, or Freyn's subsidiary, the Open Hearth Combustion Co. Freyn has ceased to be a company subsidiary and is now a department of the Engineering & Construction Div.

Robert Gregg has retired as president of the Tennessee Coal, Iron and Railroad Co., and is succeeded by *Arthur V. Wiebel. J. M. Spearman* assumes Mr. Wiebel's former position as vice president in charge of operations.

SKF Industries, Inc. has announced the appointment of *Gunnar Palmgren,* chief engineer, as assistant vice president.

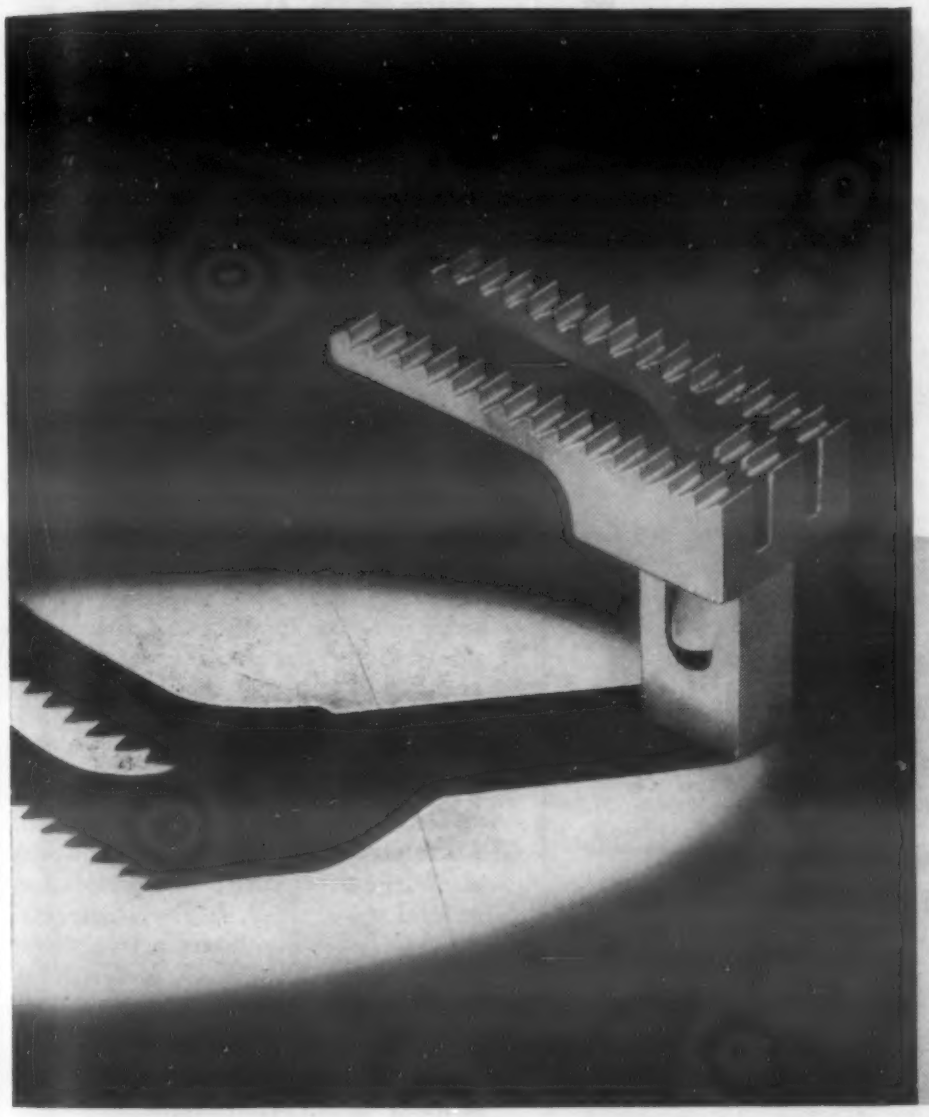
William J. Fleming, formerly vice president in charge of engineering at the Trumbull Electric Manufacturing Co., was transferred to the General Electric X-Ray Corp. as vice president in charge of engineering and manufacturing.

Standard Varnish Works has announced the appointment of *Raymond F. Hart* to the position of assistant to the president. At the same time, *Arthur E. Kromer* was named chief chemist of the Trade Sales Div.

Lorenzo Semple was elected vice president and treasurer of the United States Pipe and Foundry Co. Simultaneously, *John W. Brennan* was named secretary. These positions were filled due to the

16 times the LIFE at ½ the COST

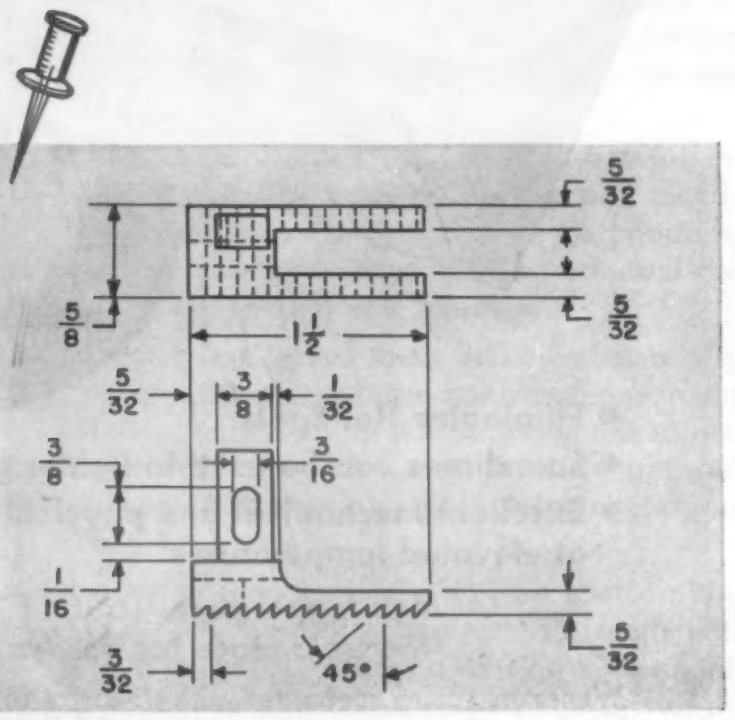
by HAYNES Investment Casting



This feed dog is used on an industrial sewing machine that makes burlap bags. Formerly, 25,000 bags were produced before the feed dogs wore out. Now these parts are still in use after production of more than 400,000 bags, because they are precision-investment-cast from the hard and wear-resistant alloy, HAYNES STELLITE Star J-Metal. Besides operating more efficiently, the feed dogs are produced by the HAYNES investment-casting process at half the former price.

Use of Better Alloys Now Possible

Because virtually any alloy can be investment-cast, there is no longer any need to consider machinability in materials selection. The alloy can be chosen solely for its ability to withstand the conditions of operation. It can then be fabricated by investment casting to such close tolerances that little, if any, finishing is required.



Illustrated Booklet Available

The booklet, "Investment Castings," gives tips in designing parts to be produced by the HAYNES investment-casting process. Call or write the nearest district office for a copy.

HAYNES alloys
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SAVES 30% OF HARD TO GET ALLOYS LIKE NICKEL, COLUMBIUM, COBALT, CHROMIUM

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- **Excellent mechanical and physical properties at elevated temperatures**

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Wherever you're confronted with structural failure in stainless sheets because of warping and cracking and local burn-through due to poor heat conductivity . . . *Rosslyn Metal* should be investigated. Because it conducts heat so well, it is often unnecessary to build for extra strength to combat the effects of hot spotting when *Rosslyn Metal* is used.

Rosslyn Metal can be fabricated easily by any of the common methods . . . welding, punching, deep drawing, spinning, etc.

These and other advantages can result from your use of *Rosslyn Metal*.

Full technical data on request

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News Digest

resignation of *Donald Ross*, who became first vice president of the United Concrete Pipe Corp., a partially-owned subsidiary of U. S. Pipe and Foundry.

Charles H. Besly & Co. has elected *Norman C. Minehart* as vice president in charge of the Abrasive Div. It was also announced that *Jack T. LeBeau* was named manager of the Abrasive Dept.

F. L. Yetter has rejoined C. H. Wheeler Manufacturing Co. as senior vice president after a 20-month period serving as director of foreign affairs for the Kuljian Corp.

The president of the Gerity-Michigan Corp — *James Gerity, Jr.* — has been elected a director of the Doehler-Jarvis Corp.

Ray F. Sparrow has been named senior vice president of P. R. Mallory & Co., Inc.

The resignation of *Charles C. Gordon* as president of Sterling Bolt Co. has been announced. *Herbert Gordon* assumes the presidency. At the same time, *Harry Dorph* resigned, after being associated with the company since its inception. Charles Gordon will become chairman of the board, and Mr. Dorph will continue to serve on the board of directors. *P. T. Phillips*, secretary, was elected vice president and secretary.

New executive officers for D. J. Murray Manufacturing Co. include the following: *A. W. Plier*, executive vice president and general manager; *D. J. Everest*, vice president; *C. L. Durkee*, director, vice president and sales manager; *W. A. Marquardt*, secretary; *P. W. Hoeper*, assistant secretary; and *Grover Keeth*, assistant treasurer.

W. C. Snyder, Jr., vice president and manager of the Metallurgical Dept. of the Division, will head the Freyn Dept. No other changes in organization or operation are contemplated.

Franklin G. Smith was elected chairman of The Ohio Rubber Co. and General *Hermon F. Safford* succeeds Mr. Smith as president of the company.

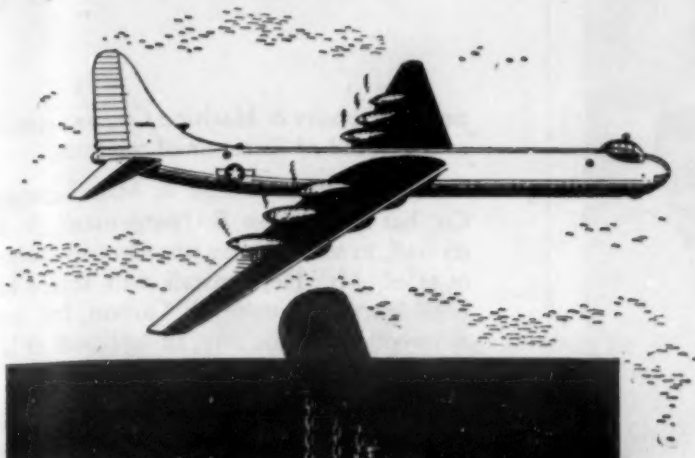
Walter Kidde & Co., Inc., has named *A. P. Hall* a member of its board of directors. Mr. Hall is vice president and general manager of sales for the American Chain & Cable Co.

Benjamin Ozaroff has joined the Fidelity Tube Corp. as president of the concern. He previously was associated with the Elgin American Co. as division manager.

Chicago Wheel & Manufacturing Co. has announced the appointment of *Arthur T. Dalton*, secretary, to the Advisory Committee, Abrasive Industry of the National Production Authority.

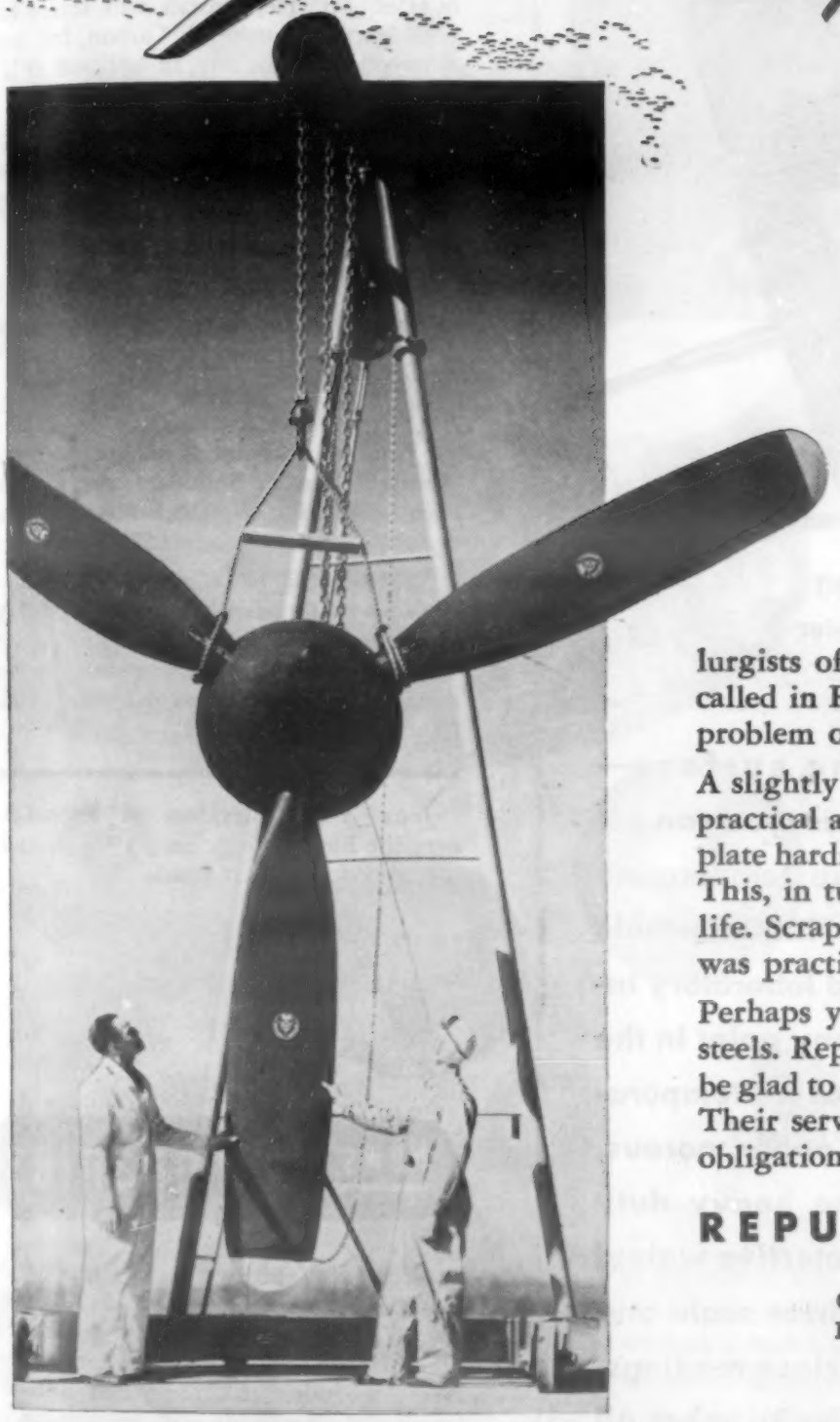
H. A. Forsberg, vice president of Conti-

Republic Metallurgical Service



Reduces SCRAP LOSS, *Improves* MACHINABILITY

for leading aircraft propeller manufacturer



To achieve in a hollow steel structure the complex curvatures and delicate balance required in a propeller blade, many unusual forming and welding operations are required. This is particularly true in fabricating alloy steel plate into finished blades for such sky giants as the B-36 and B-29. Investments in machining time are high.

Wih the object of improving machinability, lengthening tool life and minimizing scrap losses, metallurgists of the Propeller Division, Curtiss-Wright Corporation, called in Republic Steel metallurgists. Together they attacked the problem of modifying plate hardness and structure.

A slightly revised chemistry was agreed upon, and a commercially practical annealing cycle was developed. Results were immediate: plate hardness and structure were brought within acceptable limits. This, in turn, gave improved formability, machinability and tool life. Scrap loss in preliminary machining and forming operations was practically eliminated.

Perhaps you have a question concerning your own use of alloy steels. Republic metallurgical, machining and technical staffs will be glad to go to work on it in cooperation with your own personnel. Their service is completely confidential, of course, and carries no obligation. Just write:

REPUBLIC STEEL CORPORATION

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3-DIMENSION Metallurgical Service

...combines the extensive experience and coordinated abilities of Republic's *Field*, *Mill* and *Laboratory* Metallurgists with the knowledge and skills of your own engineers. It has helped guide users of Alloy Steels in countless industries to the correct steel and its most efficient usage, IT CAN DO THE SAME FOR YOU.

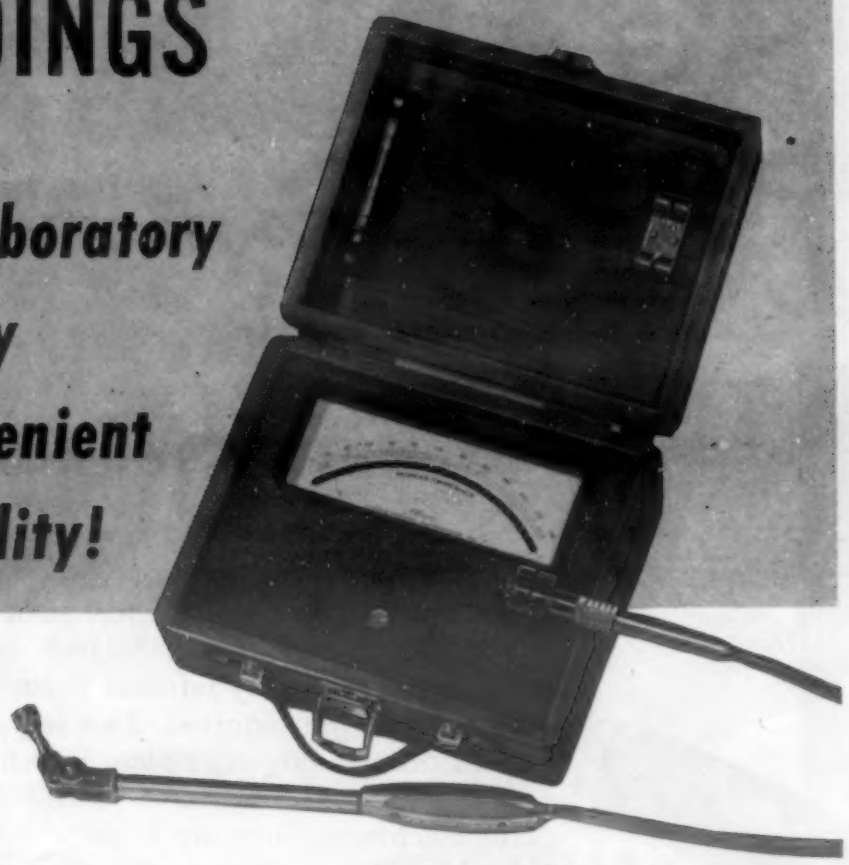
Republic ALLOY STEELS

REPUBLIC STEEL

Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Plates, Pipe, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

SURFACE TEMPERATURE READINGS

with laboratory accuracy ...convenient portability!



Alnor type 4200
Portable Pyrometer

Whatever the surface—wherever it may be—you can get instantaneous, precise temperature readings with the Alnor type 4200 Portable Pyrometer. This self-contained laboratory instrument is easily carried to any point in the plant or field to instantly measure temperature of plastic, metal, wood, paper, porous, even viscous materials. The heavy duty movement is mounted in a protective walnut case; has a large six-inch mirror scale and knife-edge pointer for quick, close readings. Eleven types of thermocouples to meet all conditions . . . seven standard scale ranges to suit your particular requirements.

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Room 522, 420 N. La Salle St., Chicago 10, Ill.

Alnor **PRECISION INSTRUMENTS FOR EVERY INDUSTRY**

News Digest

nental Foundry & Machine Co., was elected to the board of directors of the firm.

The American Forge & Manufacturing Co. has added *Sam B. Heppenstall, Jr.* to its staff, to serve as vice president-in-charge-of-sales. Mr. Heppenstall will retain his presidency of Pittsburgh Carbon, Inc. and Artwood Exhibits, Inc. in addition to his new position with American Forge.

John R. Howland, previously assistant to the president of Zenith Radio Corp. has joined Stewart-Warner Corp. as head of its newly-created Corporation Office of Product Research.

W. R. Persons was promoted from general sales manager to the position of vice president in-charge-of-sales for The Lincoln Electric Co.

The retirement of *Charles H. Disch* after 44 years of continuous service with the Wrought Washer Manufacturing Co. has been announced. Mr. Disch was vice president and director of purchases when he retired.

Charles F. Alexander, formerly assistant general manager of manufacturing for the Cherry-Burrell Corp., has joined the National Safety Council as manager of the Industrial Dept.

John Avery, president of Roots-Connersville Blower Corp. since 1946, recently succumbed to a heart attack.

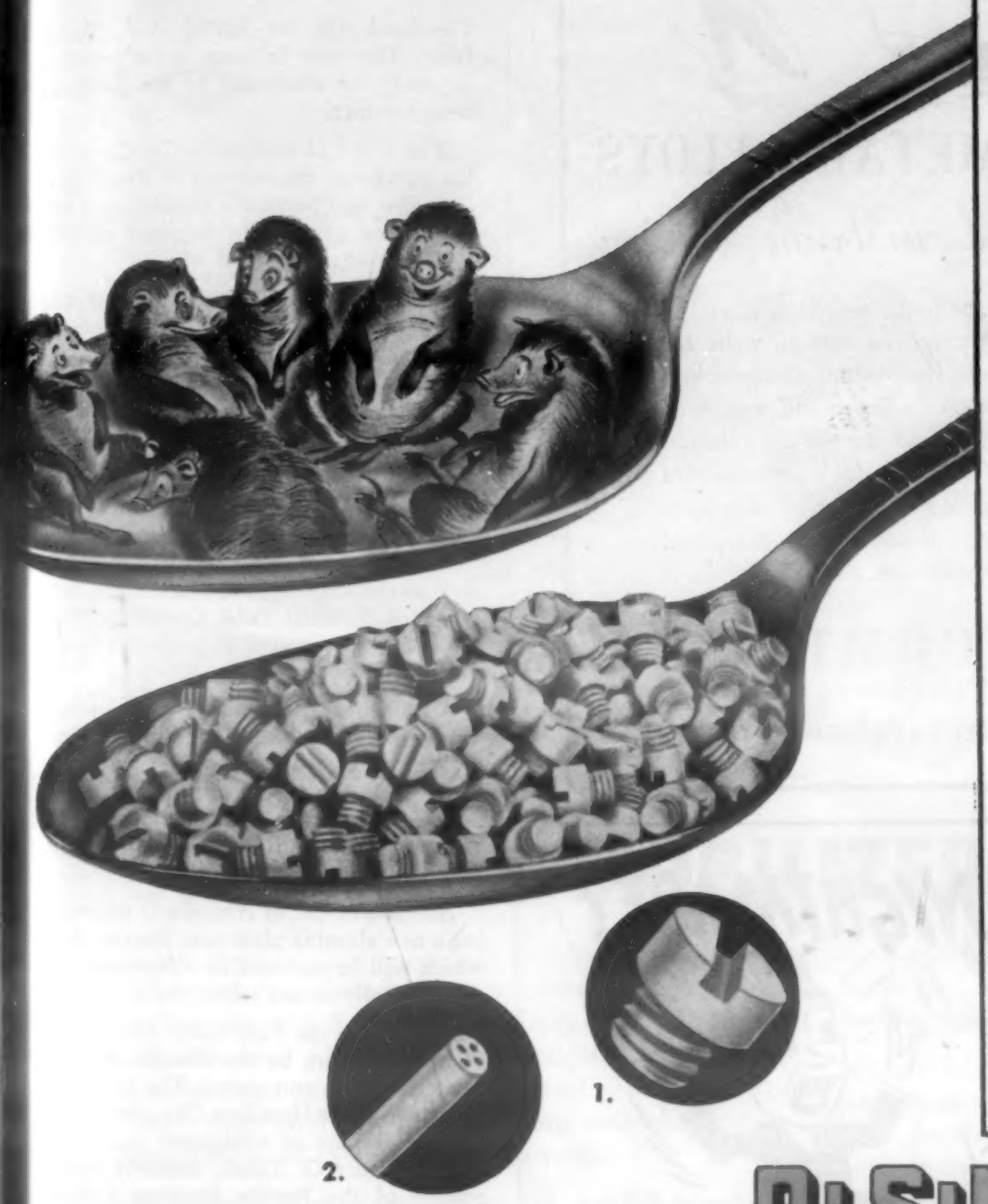
News of Companies

Acquisition of two new buildings in Germantown, Pa., by *Leeds & Northrup Co.,* Philadelphia, has been announced. One plant is located at Castor and Sedgley Aves., the other at Collum and Rubicam Sts. Some operations will be transferred to the new facilities, but the principal manufacturing and other activities of the firm will continue to be centered at the main plant at 4901 Stenton Ave.

Bendix Aviation Corp. has purchased the property and facilities of the *Victor Animatograph Corp.,* Davenport, Iowa. It will be known as a division of Bendix, under the supervision of Raymond P. Lansing, Bendix vice president and group executive.

A new plant will be constructed by *The Reliance Electric & Engineering Co.,*

It's a fact that



An interesting fact of nature is that newborn opossums weigh not more than 4 grains and are not usually longer than one-half inch. Six of them can easily be held in a tablespoon.

1. The same spoon will contain several hundred ceramic screws 0.150" long, 0.086" screw diameter complete with slotted head, precision threads #2-56 and 0.018" diameter hole through the center. These have been successfully produced in AlSiMag in production quantities! (Illustration is enlarged approximately five times.)

2. AlSiMag ceramic tubes 0.035" O.D. with 4 holes 0.006" I.D. are regularly and economically produced within tolerances of ±0.002". (Illustration enlarged approximately seven times.)

More than 70 different raw materials are kept in stock in five large warehouse areas for production of the versatile AlSiMag technical ceramics.

Over two million AlSiMag ceramic pieces are produced and shipped each day. On many days the production is well in excess of three million pieces.

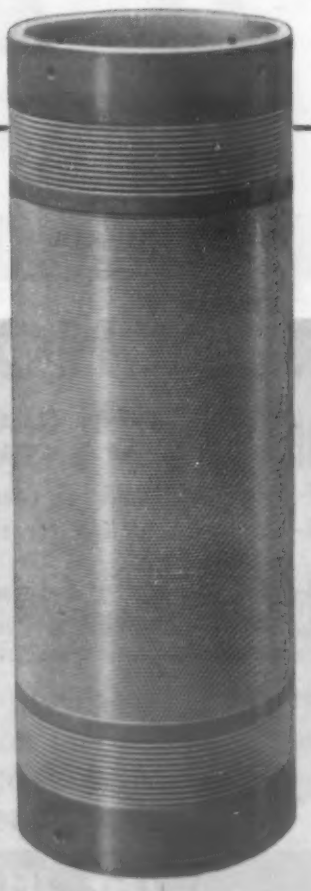
More than five thousand completely different custom made designs are made in AlSiMag each year.

3. Glazed coil forms, 8" in diameter, 23½" long with various pitch threads are made to a tolerance of ±2%, nothing less than ±0.12.

1.

2.

3.



AlSiMag
TRADE MARK REG. U.S. PAT. OFF.

A leading designing engineer visited our plant to work out a particularly difficult problem. Within a week, hand made samples were produced which fully met his requirements.

Asked what had impressed him most he said: "Your amazing versatility. We had no idea this could be done at all and you have shown us several ways you can do it. We have done business with you for years but until this visit I had no idea of the control you have over physical characteristics of your material. Your ability to economically produce complex shapes within close tolerances is far ahead of anything we have ever known. And I am greatly impressed by the modern equipment and the tremendous size of this business which makes nothing but technical ceramics."

We believe that you, too, will find here the answer to almost any technical ceramic problem.

AMERICAN LAVA CORPORATION

49TH YEAR OF CERAMIC LEADERSHIP

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. . . AND IN THE AIR . . .

. . . SEA . . .

ON LAND . . .

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aid precision control and instrumentation

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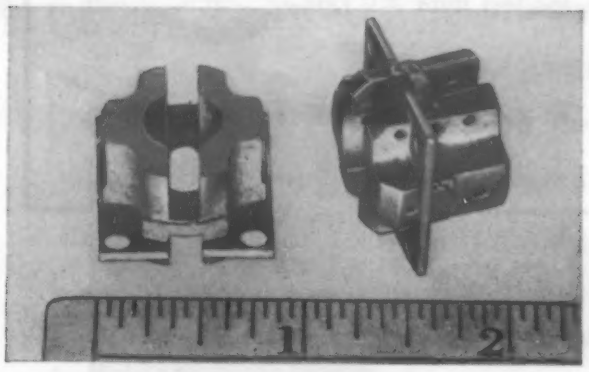

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IF YOUR MANUFACTURING PROBLEM ENTAILS—

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IN NON-FERROUS METALS

- Improved physical properties due to centrifugal casting pressure.
- Smooth surfaces and dimensional accuracy reduce finishing time.

THE JELRUS COMPANY, INC.

Precision Investment Casting & Equipment

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News Digest

Cleveland 10, on Euclid Ave., Euclid, Ohio. The new facilities are expected to be ready for occupancy by the middle of next summer.

The Brush Development Co., Cleveland, has purchased the business of *The Faxfilm Co.*, also in Cleveland. Faxfilm will now be located at the Brush plant at 3405 Perkins Ave., Cleveland 14.

Purchase of the Thomas M. Royal plant in Philadelphia, plus additional property adjacent to the plant, has been announced by the *Brown Industrial Div.* of *Minneapolis-Honeywell Regulator Co.*, Philadelphia.

The National Tube Co., a subsidiary of United States Steel Corp., plans to install a large extrusion plant for the manufacture of high alloy seamless specialty tubes, as well as shapes and bars, at the Gary, Ind., works of National Tube. Operation of the new plant is expected to begin before the end of 1951.

Successful completion of its first ten years of service to the public was celebrated recently by *Eutectic Welding Alloys Corp.*, New York 13. At the same time Eutectic announced that its new Engineering and General Offices Building will be ready for occupancy this month.

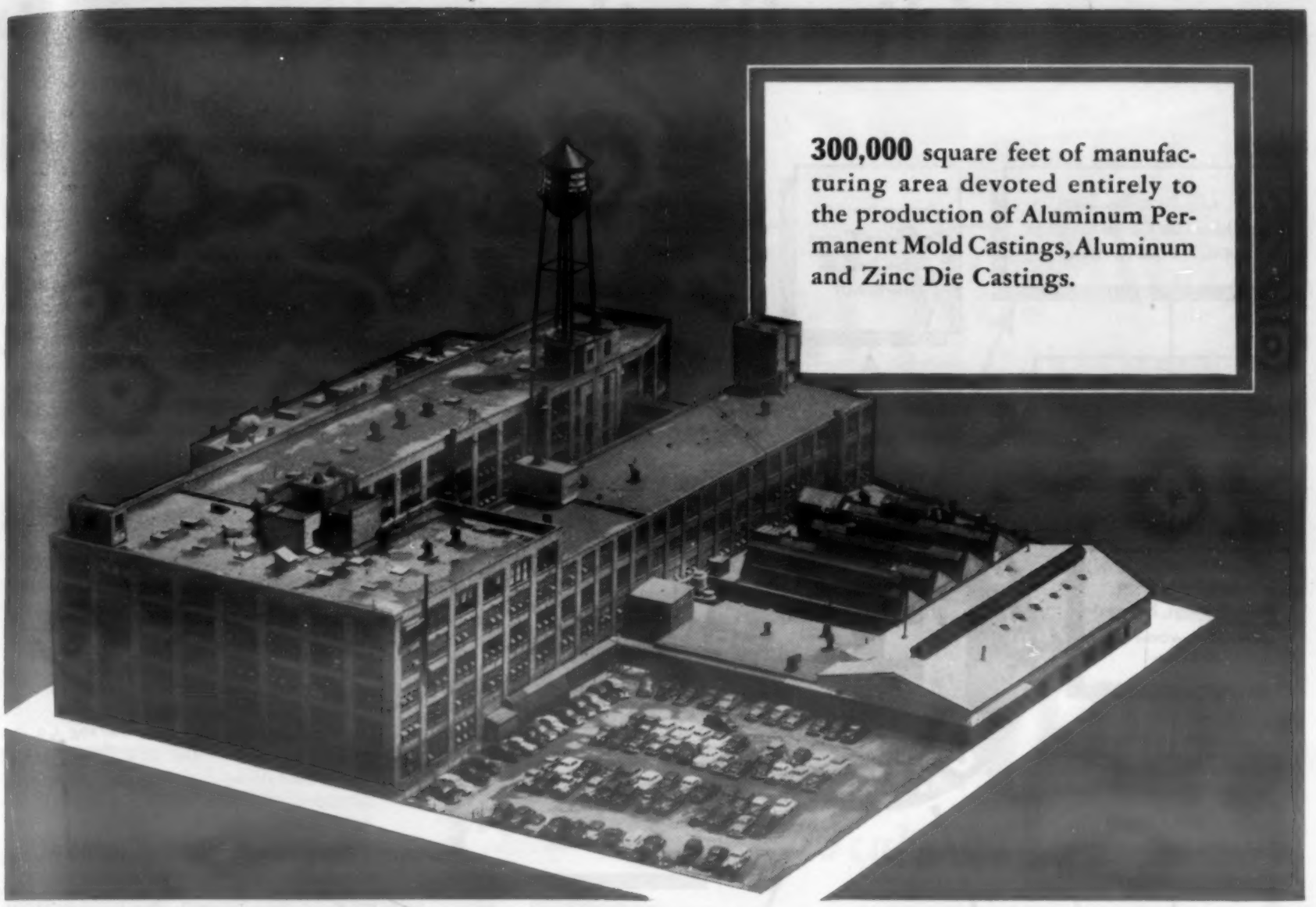
Aluminum Co. of America is constructing a new alumina plant near Bauxite, Ark., which will be operated by *Aluminum Ore Co.*, a wholly-owned subsidiary of Alcoa.

Purchase of the Ford Motor Co. plant at Hamilton, Ohio, by the *Bendix Aviation Corp.* has been announced. The plant will be known as the Hamilton Div., production starting as soon as equipment can be installed. Henry G. Tarter, formerly an executive of the Bendix Products Div. at South Bend, Ind., will be general manager of the new division.

Transactions have been completed of a merger of the *Townsend Co.*, New Brighton, Pa., and the *Cherry Rivet Co.*, Los Angeles, Calif. The West Coast plant will operate as the *Cherry Rivet Co., Div of Townsend Co.* William B. Hubbard, previously president of Cherry, was elecetd to the Townsend board of directors and will be managing director of the Cherry Div.

Worthington Pump and Machinery Corp., Harrison, N. J., has acquired the land, buildings and equipment of *National Transit Pump and Machine Co.*, Oil City, Pa. It was also announced that the *Worthington-Gamon Meter Co.*, Newark, N. J.—formerly a subsidiary of Worthington Pump—has been made a division of the concern. Robert R. Anderson, president of the subsidiary, was elected a vice president of Worthington Pump and will act as general manager of the new division.

A new manufacturing and fabrication plant has been established at 333 N.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Monarch welcomes the opportunity to work with you today in giving the widest possible casting or assembly services, utilizing the full scope of Monarch's unique facilities.

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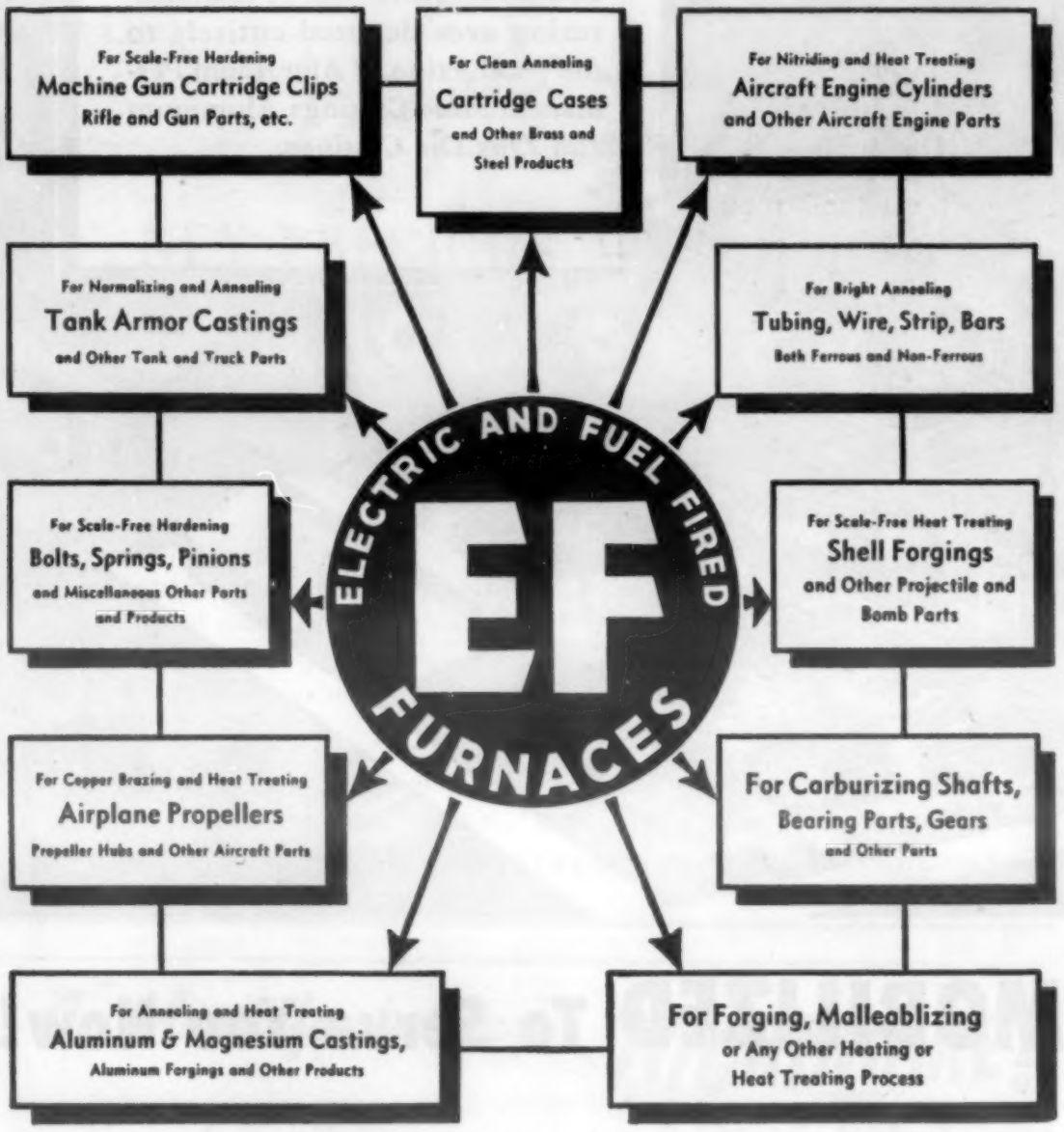

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News Digest

Meridian Rd., Youngstown, Ohio, by the *Swedlow Plastics Co.* Fred Stefan was named general manager. Another branch was also opened by Swedlow at 3435 Malt Ave., Los Angeles 22.

Barrett-Cravens Co., Chicago 9, has announced a merger with the *Crescent Truck Co.*, Lebanon, Pa. All sales will be conducted from the Chicago office, while engineering and manufacturing operations will be continued at Lebanon. No major changes in personnel are contemplated at this time.

Headquarters of the *Bennett Machinery Co.* have been moved from the Hudson Terminal Bldg. in New York to its plant and warehouse in Clifton, N. J., where a recently completed office building adjoins the plant.

The Machinery Manufacturing Co. has reorganized under the new firm name of *Diversified Metal Products Co.*, with manufacturing facilities located at 5125 Alcoa Ave., Los Angeles 58.

The establishment of a new division has been announced by the *Ward Leonard Electric Co.*, Mt. Vernon, N. Y. William G. Dawson was appointed manager of the new addition, to be known as the Industrial Chrome Div.

Carl H. Krause has purchased the *Blue Seal Asbestos Corp.* at 264 Wykoff St., Brooklyn, N. Y., and will function as its president. Mr. Krause recently was associated with the Trumbull Electric Manufacturing Co. as New York works manager.

The Alfred B. King Co., New Haven, Conn., and its subsidiaries—*Churchward Welding Accessories* and *KIF Industrial Fabricators*—have moved to a new plant in North Haven, Conn.

A new electric furnace plant for the manufacture of silicon carbide abrasive at Cap-de-la Madeleine, Quebec, Canada, was officially opened by the Norton Co., Worcester 6, Mass.

News of Societies

National officers for 1951 were elected at the annual national technical conference of the *Society of Plastics Engineers, Inc.* They include: president—Islyn Thomas, Thomas Manufacturing Corp.; vice president—Walter O. Bracken, Hercules Powder Co.; secretary—Walter F. Oelman, Standard Molding Corp.; and treasurer—William J. Dunnican, Synvar Corp.

The *American Society of Mechanical*

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Unique Heavy Duty Soak Tank Cleaner

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Rust and Heat-Scale Remover

Gears courtesy of
Gear Specialties, Inc.
Chicago, Ill.

Steel Gears—Case History

PROBLEM: To remove oil, greases and shop dirt from gears prior to heat treatment and to descale the gears after heat treatment without hydrogen embrittlement and with a minimum of dimensional change. Complete de-rusting of various iron and steel shapes also had to be considered.

PREVIOUS PROCESS: A highly caustic cleaner for the removal of oils and greases. Raw acid for general rust and scale removal. Wire brushing for the removal of heat scale and discoloration from gears susceptible to hydrogen embrittlement and whose dimensional tolerances were very small.

PRESENT PROCESS: Diversey No. 909 for oil and grease removal and Diversey Everite for all descaling and de-rusting operations.

RESULTS: Diversey No. 909 produced decidedly cleaner surfaces than the previously used material and did it in less time! The heat treated work contained no burned oil residues.

The gears which could not be pickled previously due to tendencies for hydrogen embrittlement are safely descaled with Diversey Everite. Wire brushing operations have been eliminated. No attack occurs on the gears in spite of the fact that prolonged pickling is required to remove the heavy scale at the root of the gear teeth. And Everite produces brighter surfaces than were previously obtainable with any method.

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Metal Industries Department
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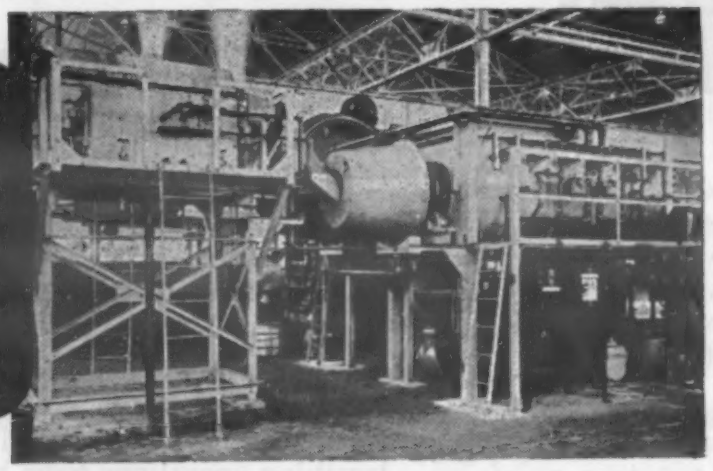

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Offer Many Advantages

For annealing, hardening and drawing small ferrous or non-ferrous metal parts which may be slowly tumbled during slow helical progression through the retort, this Rockwell Furnace exposes all pieces at the same heating rate and time under controlled conditions of temperature and atmosphere.

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News Digest

Engineers elected J. Calvin Brown, engineer and patent attorney, as president for the forthcoming year. Regional vice presidents elected include Henry R. Kessler, Republic Flow Meters Co.; Stephen D. Moxley, American Cast Iron Pipe Co.; Dr. John T. Rettaliata, Illinois Institute of Technology; and Carl J. Eckhardt, University of Texas.

Hugh Latimer Dryden, director of the N.A.C.A., was the recipient of the Daniel Guggenheim Award for 1950, in recognition of his outstanding leadership in aeronautical research and fundamental contributions to aeronautical science. The Award was presented jointly by the *American Society of Mechanical Engineers, Institute of the Aeronautical Sciences,* and *Society of Automotive Engineers.*

John G. Bucuss, general manager of the Strapping Div., Acme Steel Co., was elected president of the *Materials Handling Institute* for 1951.

The establishment of a National Asphalt Research Center at the *Franklin Institute* Laboratories for Research and Development has been announced.

The *Cast Iron Soil Pipe Institute* has opened a Washington office in the Heurich Bldg., 1627 K St., N. W., Washington 6, D. C.

Thomas D. Jolly, vice president of the Aluminum Co. of America, has been elected president of the *American Standards Assn.* This will be his third one-year term as president.

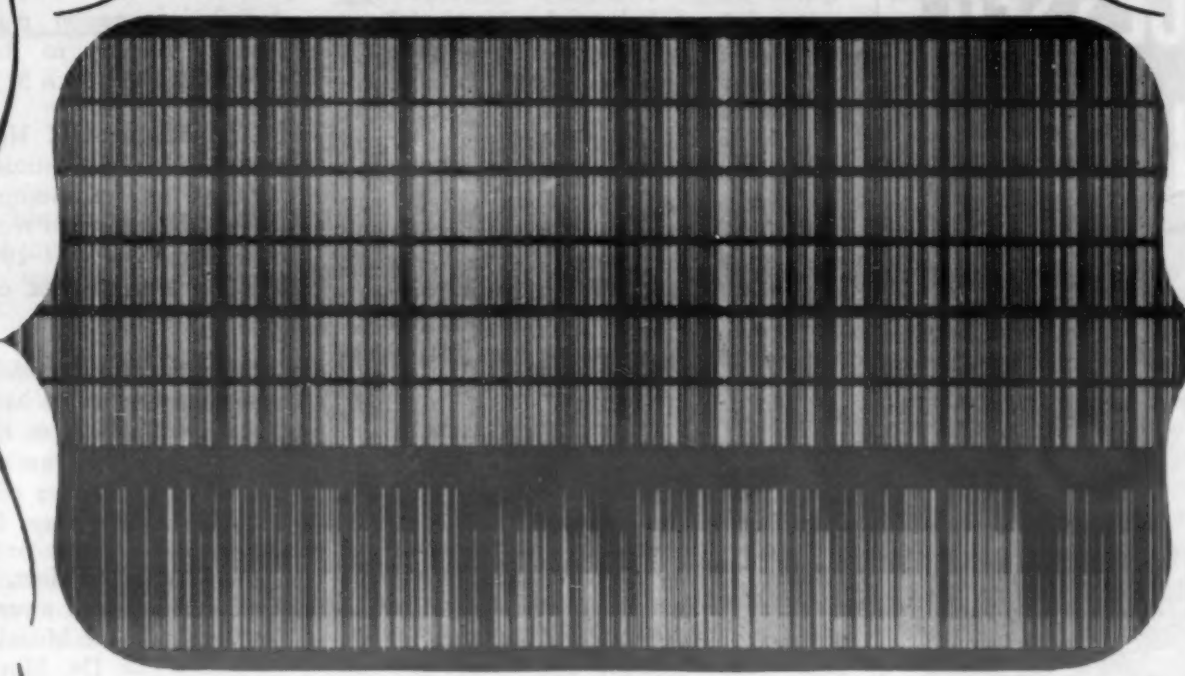
The recipient of the Albert Victor Bleininger Award of 1950 will be Dr. John C. Hostetter, recent president of the Mississippi Glass Co. The Award is conferred by the Pittsburgh Section of the *American Ceramic Society* for distinguished achievement in the field of ceramics.

A gift of $5,250,000 from the *Alfred P. Sloan Foundation, Inc.,* for the establishment of a School of Industrial Management has been presented to the *Massachusetts Institute of Technology.* The new school will be housed in a building adjoining the Institute's grounds.

National Foremen's Institute, Inc., has established an expanded supervisory training department, to be headed by Gustav R. Stahl, for 12 years editor of the magazine *Supervision.*

Lute J. Parkinson, prominent mining consultant, was presented with the *Colorado School of Mines* Distinguished Achievement Award, which is given to graduates who make outstanding records in the mineral industries field, and who bring credit to themselves and the Colorado School of Mines.

Birth Certificate OF A STOODY ALLOY



THESE LINES tell a secret story to trained eyes—They define definite welding characteristics before ever an arc is struck . . . They indicate high wear resistance before a deposit is laid . . . They're an Open Sesame to the contents of a Stoody Alloy from the moment of its completion.

Spectrographic examinations such as this are a routine operation in the manufacture of each heat of every Stoody Alloy. The analysis is speedily obtained by equipment in our own laboratory. It's accurate and positive, and it's just one of the many modern, scientific precautions that insure the constant uniformity and high quality of Stoody Alloys.

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I-S springs are always expressly designed to the capabilities of the certified alloy used. Exclusive heat-treating methods—individualized for each production run—permit stress-relieving during hardening and often effect economies such as the elimination of forming dies. Our exclusive process—combined with the use of specially built machines—makes it possible for I-S to deliver finished springs that offer strength—conductivity—elasticity — drift resistance — ductility and other spring characteristics in numerous, closely controlled combinations . . . as dictated by the particular spring function your designer has in mind. You can, therefore, obtain the maximum potential from the superior spring material around which I-S unique service to designers and manufacturers has been developed.

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News Digest

The *Armour Research Foundation* of the *Illinois Institute of Technology* is offering a number of industrial research fellowships in metallurgy, electrical engineering, ceramics, mechanics, physics and chemistry, to begin in September 1951. Those persons awarded fellowships will attend the Institute half-time and work in the Foundation half-time. They will be employed full-time by the Foundation during the summer. Application forms may be obtained from the Office of Admissions, Graduate School of Illinois Institute of Technology, Chicago 16. Applications received prior to Mar. 15 will be given first consideration.

Election of four educational institutions to active membership in the *Engineering College Research Council* of the *American Society for Engineering Education* was announced. They include: *California Institute of Technology, Dartmouth College* (Thayer School of Engineering), *Montana State College,* and *University of Toledo.* Extensive activity in engineering research supplementing an effective program of undergraduate engineering education is required for election to the Research Council.

The *Resistance Welder Manufacturers' Assn.* has announced a contest for outstanding papers dealing with resistance welding subjects. Anyone, without restriction, from the United States, its possessions and Canada is eligible to enter the contest, as well as any member of the American Welding Society in any grade from any place in the world. Closing date of the contest is July 31, 1951, and detailed information may be secured by writing directly to Resistance Welding Institute, 1900 Arch St., Philadelphia 3.

Dr. William A. Hamor, assistant director of Mellon Institute, has been named by the Pittsburgh Section of the *American Chemical Society* to receive its Pittsburgh Award for the year 1950. The Award is granted annually for outstanding service to chemistry.

The *Porcelain Enamel Institute* has been presented the 1950 Merit Award of the *American Trade Assn. Executives* in recognition of the Institute's Safe Transit Program—a cooperative effort aimed at lessening product damage in shipment.

Dr. Samuel L. Hoyt, Battelle Memorial Institute, has been awarded the Outstanding Achievement Medal of the *University of Minnesota.* Dr. Hoyt's work on hard carbides and his services as technical advisor of Battelle were cited.

MANUFACTURERS' LITERATURE

Materials

Irons • Steels

Stainless Steels. Allegheny Ludlum Steel Corp., 34 pp, ill. Fabrication characteristics, available forms, properties and corrosion resistance of stainless steel types. Shows hospital uses. (1)

Corrosion Resistant Steel. Bethlehem Steel Co., 52 pp, ill, No. 259. Properties and characteristics of Mayari R low alloy, light, strong steel with high corrosion resistance. (2)

Stainless Steel Properties. The Carpenter Steel Co. Slide indicator indicates relative workability, analyses, corrosion resistance and heat treating and mechanical properties. (3)

Abrasion Resistant Alloy. Jones & Laughlin Steel Corp., 36 pp, ill, No. AD 155. Technical data on Jalloy, impact and abrasion resistant steel for rock and earth moving applications. (4)

Screw Steel. Joseph T. Ryerson & Son, Inc., 2 pp. Describes Ledloy, claimed to machine 30 to 50% faster than the fastest cutting screw steel previously available. (5)

Galvanized Steel. Sharon Steel Corp. Brochure summarizes test data on Galvanite zinc coated steel, said to fabricate like ordinary cold rolled steel, resist corrosion for years. (6)

Graphitic Steel. The Timken Roller Bearing Co., Steel & Tube Div. Data on properties and applications of graphitic steels in *Timken Graphitic Steel Data Book.* (7)

Non-Slip Steel Plate. Alan Wood Steel Co., 8 pp, ill. Specifications and characteristics of Algrip abrasive-rolled steel floor plate designed for non-skid applications. (8)

Nonferrous Metals

Beryllium Copper. The Beryllium Corp. Technical bulletins give valuable information on applications of beryllium copper alloys. (9)

Spring Alloy. Elgin National Watch Co., Industrial Products Div., 2 pp. Composition and properties of Elgiloy, cobalt-chromium-base spring alloy. (10)

Dense Alloy. Fansteel Metallurgical Corp. Bulletin describes Fansteel 77 Metal, strong, machinable alloy with density near to that of pure tungsten. (11)

Silicon Bronzes. Federated Metals Div., American Smelting and Refining Co., 4 pp, ill. Applications, typical properties and descriptions of high-strength silicon-copper alloys for casting. (12)

Aluminum Alloy. Frontier Bronze Corp. Data on Frontier 40-E aluminum alloy combining high strength, good shock and corrosion resistance and machinability. (13)

High Temperature Alloys. Haynes Stellite Div., 96 pp, ill. Detailed tables and graphs of 11 high temperature cobalt-, nickel- and iron-base alloys. Includes fabricated data. (14)

Nickel Alloy Corrosion Resistance. The International Nickel Co., Inc., 16 pp, ill, reprint. Corrosion resistance of nickel, monel and Inconel to soap and fatty acids as compared to other metals. (15)

Electrical Resistance Alloy. The C. O. Jelliff Mfg. Co. Engineering data on Jelliff Alloy 1000, said to have outstanding electrical and mechanical properties. (16)

Precious Metals. The J. M. Ney Co., 19 pp, ill, No. R-12. Properties, uses and specifications of available types of precious metal alloys for sliding electrical contacts. (17)

Nonmetallic Materials • Parts

Porcelain Insulators. The Akron Porcelain Co., 6 pp, ill. Describes engineering properties of porcelains, and indicates numerous applications as electrical insulators. (18)

Felts. American Felt Co. "SAE Felts" gives technical standards on felt materials as adopted by automotive industries and used by many others. (19)

Hard Rubber. American Hard Rubber Co., 60 pp. Manual gives detailed selection data on hard rubber and plastics materials. (20)

Model Making Stone. American Lava Corp., 4 pp, ill, No. 146. Properties and methods of heat treating lava, hydrous aluminum or magnesium silicates useful for model making. (21)

Rubber Parts. Automotive Rubber Co., Inc. Series of bulletins show use of rubber for insulation or corrosion prevention in industrial equipment. (22)

Porcelain Products. The Colonial Insulator Co., 12 pp, ill. Shows wide range of custom-made porcelain products, such as insulators and forms for dipped rubber goods. (23)

Precision Molded Plastics. Consolidated Molded Products Corp., 8 pp, ill. Describes facilities and equipment for producing molded plastics parts. (24)

Plywood. Douglas Fir Plywood Assn., 32 pp, ill. Series of articles shows how to use plywood effectively in fixtures, displays, posters and signs. (25)

Silicone Compound. Dow Corning Corp., 4 pp, ill. Data on D.C. Antifoam A, silicone compound for killing foam in aqueous solutions. Typical applications included. (26)

Plastics. E. I. du Pont de Nemours & Co. (Inc.), 10 pp, ill, No. 113/3. Descriptions, advantages and uses of Lucite, Polythene Nylon, Butacite, Pyralin, Plastacele and Teflon. (27)

Plastics. Durez Plastics & Chemicals, Inc. *Durez Plastics News* gives latest data on company's development in molding compounds, industrial resins and protective coating resins. (28)

Flexible Tubing. Flexible Tubing Corp., 8 pp, ill, No. 5-4. Applications and performance data on Spiratube, flexible tubing for ventilation and materials conveying. (29)

Laminated Plastic Parts. The Formica Co. Catalog gives full information on company's facilities for complete machining of Formica custom-made parts. (30)

Polyvinyl Plastics. B. F. Goodrich Chemical Co., 16 pp, ill. Properties and descriptions of Geon resins. Detailed applications, such as extrusions, wire and cable, and films and coatings. (31)

Rubber. B. F. Goodrich Chemical Co. Properties and applications of Hycar, high strength compression and heat resistant rubber suited to heavy duty service. (32)

Self-Lubricating Bushings. Graphite Metallizing Corp., 8 pp, ill. Describes Graphalloy grades for bushings and electrical uses. Bearing design data included. (33)

Plastic Molding. The Grigoleit Co. Folder describes this company's facilities for producing molded plastics. Includes designing, engineering, tooling, molding and finishing. (34)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on page 169.

MANUFACTURERS' LITERATURE

Corrosion Resisting Plastic. Haveg Corp., 8 pp, ill. Uses of various grades of Haveg material, asbestos with synthetic resin, for corrosion resisting process equipment. (35)

Carbon Products. Morganite, Inc., 8 pp, ill, No. 1f. Specifications of various carbon bearings and bushings; also properties of six series of Morganite products. (36)

Thermosetting Plastic. Plaskon Div., Libbey Owens Ford Glass Co., 2 pp, ill. Practical application of Plaskon Alkyd, indicating valuable properties of special plastic for high-speed compression molding. (37)

Molded Parts. Resistoflex Corp., 4 pp, ill, No. 4g/3. Properties and uses of firm's nonmetallic custom-molded parts and resinous-lined, reinforced industrial hose. (38)

Alumina. Reynolds Metals Co., 8 pp, ill. Description of production of alumina and its application to such materials as plastics, paints, alloy steels and inks. (39)

Sponge Rubber. Sponge Rubber Products Co., 12 pp, ill. Specifications and descriptions of Spongex products, including sheet, die cut, cord and strip sponge rubber shapes. (40)

Molded Ceramics. Star Porcelain Co. Gives technical data on characteristics of molded ceramic products for electrical wiring, electrical heating and special purposes. (41)

Rubber Parts. Tyer Rubber Co., 4 pp, ill, No. 1c. Describes design and molding service for rubber parts specified by industry. (42)

Carbon-Graphite Parts. U. S. Graphite Co., 68 pp, ill, No. G-49. Detailed properties, chemical resistance, assembly information, design aids, 60 applications and limitations of Graphitar. (43)

Polyvinyl Resins. U. S. Rubber Co., Naugatuck Chemical Div., 20 pp, ill. Detailed properties, ingredients, compounding and processing of Marvinol polyvinyl chloride resins. (44)

Industrial Plastic. Westinghouse Electric Corp., 36 pp, ill. Properties, applications and advantages of Micarta industrial plastic given with selection tables for molded and laminated types. (45)

Flexible Hose. The Wiremold Co., 4 pp, ill, No. 567. Description, applications and types of this firm's flexible, reinforced rubber air ducts for finishing applications. (46)

Metal Parts • Forms

Precision Investment Castings. The Adapti Co., 4 pp, ill. Close tolerances and stronger metals are among advantages listed for Adapti Method of precision casting. (47)

Precision Castings. Alloy Precision Castings Co., 8 pp, ill. Describes frozen mercury method of precision casting, its application to difficult castings, and facilities for custom fabrication. (48)

Aluminum Die Castings. Aluminum Co. of America. Book contains detailed technical information for effective design of aluminum die castings. (49)

Aluminum Extrusions. Aluminum Co. of America. Design potentials of extrusion process and cost savings in fabrication and assembly of extrusions explained. (50)

Aluminum Parts. Aluminum Goods Mfg. Co., 56 pp, ill. Catalog covers extensive production facilities and technical services for producing wide range of parts. (51)

Certified Die Castings. American Die Casting Institute, Inc. Discusses plan to protect zinc alloy die castings buyers by subjecting producers products to regular testing. (52)

Bonded Metals. American Nickeloid Co., 16 pp, ill. Fabricating information and suggestions, applications and tables of properties and sizes of nickeloid metal sheets. (53)

Nonferrous Plaster Mold Castings. Atlantic Casting & Engineering Corp., No. 4. Describes production of copper-base and aluminum alloy "Atlanticastings." (54)

Welded Steel Tubing. Brainard Steel Co., Tubing Div., 8 pp, ill. Shows facilities for manufacturing welded steel tubing, its applications, fabrication and specifications. (55)

Steel Tubing. Bundy Tubing Co., 20 pp, ill. Properties, specifications and typical parts of Bundyweld double-walled, copper-coated steel tubing. (56)

Cemented Carbide Products. Carboloy Co., 60 pp, ill, No. GT-250. Specifications and applications of this company's cemented carbide tools and blanks, both standard and made to order. (57)

Thermostatic Bimetal. W. M. Chace Co., 4 pp, ill, No. 1a/10. Properties of thermostatic bimetals and formulae to use in application to temperature responsive devices. (58)

Powdered Metal Parts. Chicago Powdered Metal Products Co., 4 pp, ill. Properties and advantages of Camet custom-molded powdered metal parts. Includes design types. (59)

Steel Castings. Continental Foundry & Machine Co., 32 pp, ill. Booklet presents 12 considerations that should be taken into account in buying steel castings. (60)

Corrosion Resistant Alloy Castings. The Cooper Alloy Foundry Co., 4 pp. Indicates resistance of corrosion resistant alloys against approximately 400 corrosive chemicals. (61)

Plastic Lined Fittings. The Dow Chemical Co., 32 pp, ill, No. SL6-N-250. Properties, design data and applications of Saran-lined steel and iron pipe, fittings and valves. (62)

Nickel Alloy Products. Driver-Harris Co., 4 pp, ill, Vol. X, No. 2. *D-H Alloy Craftsman* describes various applications of Nichrome and monel wires and forms. (63)

Metal and Plastics Parts. The Electric Auto-Lite Co., Bay Mfg. Div., 16 pp, ill. Examples of wide variety of ornamental and functional custom-made parts. (64)

Die Cast Parts. The Electric Auto-Lite Co., Die Casting Div., 16 pp, ill, No. G137. Describes facilities for economical manufacture of quality die castings. (65)

Stainless Tubing. Peter A. Frasse & Co., 12 pp. Data on machining seamless mechanical tubing, including recommendations for tool design. (66)

Laminated Metals. General Plate Div., Metals & Controls Corp., 4 pp, ill, No. 1a. Properties and uses of various laminated metals, including precious metals overlays and laminated silver contacts. (67)

Die Castings. The Hoover Co., Die Casting Div. Basic information on die castings, what they are, how this company produces them to customers' specifications, and recommendations for design. (68)

Iron Castings. Hunt-Spiller Mfg. Corp. Properties and descriptions of Gun Iron and many other metals for casting. (69)

Permanent Magnets. Indiana Steel Products Co., 34 pp, *Permanent Magnet Manual*, No. 3. Uses, types and materials of permanent magnets. Includes design data. (70)

Precision Castings. The Jelrus Co., Inc., 4 pp, ill. Advantages, possible tolerances and economies obtainable by specifiers of intricate machine parts using precision casting. (71)

Aluminum Cable. Kaiser Aluminum and Chemical Corp. Details on properties of Kaiser Aluminum ACSR and All-Aluminum Cable. Gives available reel sizes. (72)

Aluminum Extruded Shapes. Light Metals Corp., 6 pp, ill. Shows facilities for producing to order a variety of indicated aluminum fabrications and extruded shapes. (73)

Deep-Drawn Shapes. Linde Air Products Co. Complete information on Prest-O-Lite deep-drawn shapes and shells, including applications and design aids. (74)

Gray Iron Castings. Meehanite Metal Corp., 8 pp, ill, No. 30. One of a series of bulletins describing the current uses of Meehanite gray iron castings. (75)

Tungsten Carbide Forms. Metal Carbides

MANUFACTURERS' LITERATURE

Bolts, Nuts and Studs. Pawtucket Manufacturing Co., 28 pp, No. 46. Complete price catalog of this company's fasteners of brass, bronze, stainless steel and monel. (143)

Welding Positioners. Ransome Machinery Co., Industrial Div., 36 pp, ill, No. 210 C. Description, features and applications of 100- to 40,000-lb. capacity welding positioners. (144)

Bench Welder. Raytheon Manufacturing Co., 2 pp, ill. Features, specifications and advantages of Raytheon bench welder claimed to enable precise welding by several methods. (145)

Self-Locking Nuts. Shakeproof, Inc., 6 pp, ill, No. 1. Illustrates seven applications of Keps pre-assembled nuts and lockwashers to otherwise difficult bolted assemblies. (146)

Special Fasteners. South Chester Corp., Southco Div., 6 pp, ill, No. SCO 12. Descriptions and specifications of special fasteners for unique fastening applications. (147)

Carbon Arc Welding. Speer Carbon Co., 8 pp, ill. Advantages of carbon arc welding for fabricating and repairing alloy and nonferrous metals. (148)

Resistance Welding Control. Westinghouse Electric Corp., Industrial Control Div., 16 pp, ill, No. B-4309. Features of electronic welding controls designed for simple, versatile application. (149)

Forming • Casting • Molding • Machining

Forged Metal Quality. Drop Forging Assn., 6 pp, ill. Describes hot working processes in detail; emphasizes improvements in physical properties achieved by hot working metals. (150)

Die Casting Machines. Kux Machine Co., ill. Catalog shows specifications and applications of complete line of this company's die casting machines. (151)

Plastics Molding Press. F. J. Stokes Machine Co., 4 pp, ill, No. 503. Description and specifications for automatic plastics press. Typical products shown. (152)

Machine Laminated Plastics. Synthane Corp., 6 pp, ill. Recommended techniques for common machining operations on laminated plastics. Includes properties and design hints. (153)

Multiple Hole Punching. Wales-Strippit Corp., 8 pp, ill. Features, applications, parts and typical setups of multiple hole punching systems for rapidly punching sheet parts. (154)

Inspection • Testing • Control

Thermocouples. Charles Engelhard, Inc., No. 330-D. Shows features of full line of this company's noble metal thermocouples. (155)

Paint Flexibility Tester. Henry A. Gardner Laboratory, Inc. Describes mandrel set with nine rods of various diameters, and tin plates to be painted and bent. (156)

Batch Mixer for Testing. Claud S. Gordon Co., 1 p, ill. Describes 4-qt. stainless steel batch mixer for thoroughly mixing small amounts of sample mixtures for test purposes. (157)

Bend Testing Machine. Krouse Testing Machine Co., 4 pp, ill, No. 46-W. Specifications and description of high capacity repeated bending machine. (158)

Compression Tester. National Forge and Ordnance Co., 2 pp, ill, No. 492. Description, features and uses of sensitive, sturdy low-capacity-compression-crush testing machine. (159)

Testing Machines. Scott Testers, Inc., 6 pp, ill, No. 50. Catalog gives details on complete line of instruments for testing mechanical properties of materials. (160)

Rubber Testing. V. L. Smithers Laboratories, 16 pp, ill. Describes facilities for testing chemical, physical and mechanical properties of rubber, synthetic rubber and rubber-like materials. (161)

Ultrasonic Thickness Gage. Sperry Products, Inc., 4 pp, ill, No. 3700. Description, operating instruction and basic theory of Reflectogage, ultrasonic thickness tester and flaw detector. (162)

Abrasion Testing Set. Taber Instrument Corp., 6 pp, ill, No. 5003. Equipment and applications of Model 140 abraser for testing abrasion resistance of surfaces. (163)

Moisture Meter. Tagliabue Instruments Div., 4 pp, ill, No. 1263 A. Applications and features of Tag Dielectric Moisture Meter for measuring moisture content of materials. (164)

Thermocouples. Thermo Electric Co., Inc., No. G. Catalog shows large variety of wire-type thermocouple assemblies in many sizes. (165)

Control Instruments. Wheelco Instruments Co., 8 pp, ill, No. Z6600. Descriptions and price lists of this company's recording, controlling and indicating instruments. (166)

General

High Vacuum Pumps. Distillation Products Industries. Information on unique high vacuum pumps, economically designed for such uses as metal processing and dehydration. (167)

Industrial Carburetor. C. M. Kemp Manufacturing Co., 12 pp, ill, No. 1C-22. Capacity and dilution charts and specifications of Kemp Series "S" industrial carburetor. (168)

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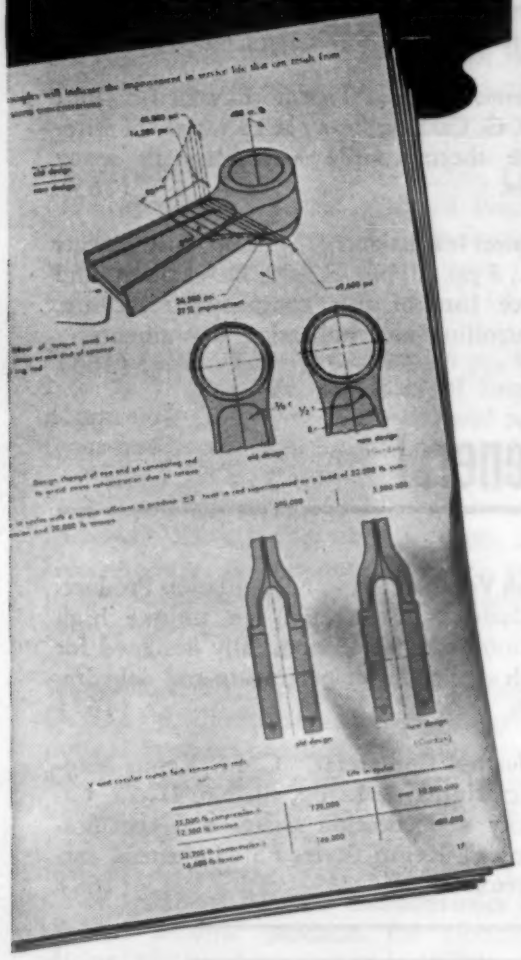

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Meetings and Expositions

WESTERN METAL CONGRESS AND EXPOSITION. Oakland, Calif. Mar. 19-23, 1951.

PRESSED METAL INSTITUTE, annual technical meeting. Cleveland. Mar. 22-23, 1951.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Open Hearth and Blast Furnace, Coke Oven and Raw Materials conference, Iron and Steel Div. Cleveland. Apr. 2-4, 1951.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, spring meeting. Atlanta, Ga. Apr. 2-5, 1951.

MIDWEST POWER CONFERENCE. Chicago. Apr. 4-6, 1951.

ELECTROCHEMICAL SOCIETY, spring meeting. Washington, D. C. Apr. 8-11, 1951.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, spring engineering conference. Pittsburgh. Apr. 9-10, 1951.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS. Institute of Metals Div., New England regional conference. New Haven, Conn., Apr. 13-14, 1951.

AMERICAN SOCIETY OF LUBRICATION ENGINEERS, national convention. Philadelphia. Apr. 16-18, 1951.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting and aircraft engineering display. New York, Apr. 16-18, 1951.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Process Industries conference. Baltimore, Md. Apr. 17-19, 1951.

AMERICAN MANAGEMENT ASSOCIATION, annual packaging exposition. Atlantic City, N. J. Apr. 17-20, 1951.

NATIONAL SCREW MACHINE PRODUCTS ASSOCIATION, spring meeting. Cincinnati. Apr. 18-21, 1951.

CUTTING DIE INSTITUTE, semi-annual spring convention. Cincinnati. Apr. 19-21, 1951.

AMERICAN CERAMIC SOCIETY, annual meeting. Chicago. Apr. 22-26, 1951.

AMERICAN FOUNDRYMEN'S SOCIETY, annual convention. Buffalo, N. Y. Apr. 23-26, 1951.

METAL POWDER ASSOCIATION, annual meeting and exhibit. Cleveland. Apr. 25-26, 1951.

ASSOCIATION OF IRON & STEEL ENGINEERS, spring conference. Detroit. Apr. 30-May 1, 1951.

MATERIALS HANDLING EXPOSITION. Chicago. Apr. 30-May 4, 1951.

INDUSTRIAL FASTENERS INSTITUTE, annual meeting. Hot Springs, Va. May 3-4, 1951.

COPPER & BRASS RESEARCH ASSOCIATION, annual meeting. Hot Springs, Va. May 6-9, 1951.

NATIONAL WELDING SUPPLY ASSOCIATION, annual convention. Cleveland. May 7-9, 1951.

GREATER NEW YORK INDUSTRIAL SHOW. New York. May 7-11, 1951.

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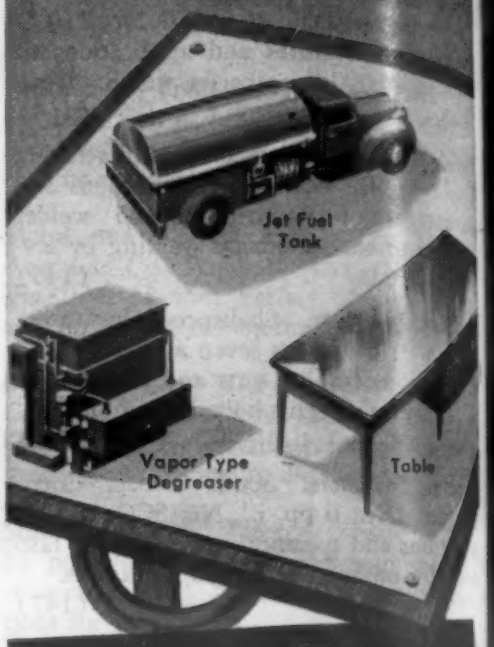

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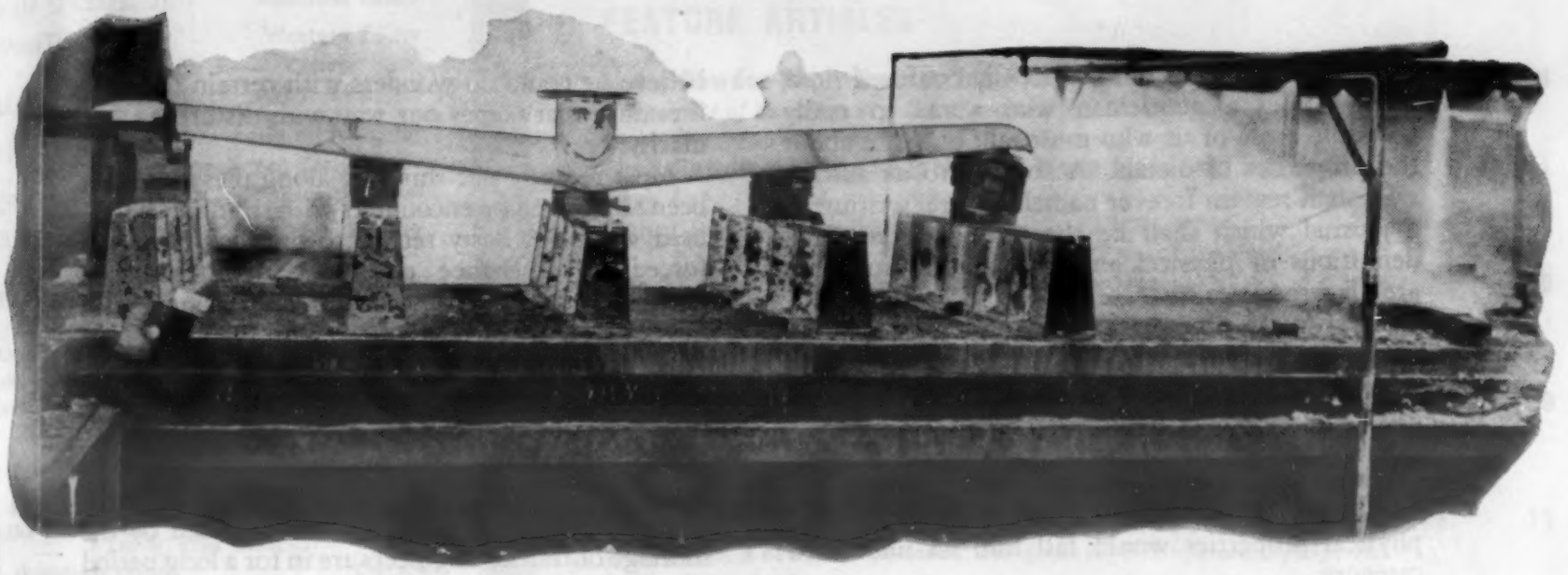

MISSOURI may be the "Show Me" state. But even after they're shown, some Missourians are still amazed by the way this Lumnite car top absorbs thermal shock at Nooter Corp., St Louis.

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The Editor's Page

As if the world is not sufficiently confused now, along comes a gentleman who wants to really befuddle those of us who must talk or write about the properties of metals. According to an author, who shall remain forever nameless here, writing in a journal which shall be the same, our accepted definitions of physical and mechanical properties are all wrong.

Mechanical properties, it is argued, are those properties which result from design. They would include such things—I'll not say properties—as dimensions, weight, fatigue, speed, endurance, tractive effort and a few others. *Physical* properties would include hardness, tensile strength, ductility, density, etc. Those characteristics *usually* known as physical properties would fall into an undecided category.

The proposed realignment of categories would be based on testing methods, and the author assumes that physical properties are so termed because they are determined by physical tests.

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I suppose this is only the start of a steady flow of similar trivia from Washington. Be that as it may, here's one we think you'll enjoy. Newsmen in the nation's capitol have been astonished at some recent trends in censorship, and here is one reason: The Army studied evaluations of Russian medium tanks, but wouldn't say for publication how thick the armor was. The reason? That information might help the enemy.

•

Interesting statistics department: In Alcoa's *News-Letter* we learn that six 400-watt mercury vapor lamps and nine 1000-watt incandescent lamps are used to illuminate the torch held aloft by the Statue of Liberty. With a remarkable display of keeping one's mind on one's business, Alcoa slip-stickers determined the electricity burned in 1 hr. to keep the torch burning is sufficient to produce 1.14 lb of aluminum.

•

Some of our editorial reading lately has made us a soft touch for the books of Dr. Rudolph Flesch. Dr. Flesch, in case you don't remember the name, has dedicated his life to making the American (as opposed to English) language understandable. His books include such intriguing titles as "The Art of Plain Talk" and "Say What You Mean." Since Dr. Flesch has made a habit of translating involved and over-pretentious language into simple words, we believe he could do wonders with certain technical literature that comes our way with disturbing regularity.

Most recently our thinking along these lines has been stimulated by encounters with strange, seldom-used words. A hasty retreat to the dictionary was forced by a chance encounter with the word "delimits." For some unaccountable reason, we had never before come face to face with the word. The word doesn't mean what one might think at first glance. It is just another way of saying defines, or establishes the limits of something.

•

Plants which have already been hobbled by the shortage of trained engineers are in for a long period of the same, according to all indications. Even before the draft and recall of reserve officers took a large number of engineers, certain types of companies were frantically looking for trained men. The situation is to get worse before it gets better, according to Dean S. C. Hollister, of the Cornell University College of Engineering. Even without the drain of manpower caused by military needs, we face a deficit of about 10,000 engineers per year every year for at least a decade.

Most of the blame for the present situation is said to rest upon a widely circulated—but false—rumor that engineers are in oversupply.

Perhaps a partial answer lies in training your own engineers, as some aircraft manufacturers are doing.

•

Were you ever sent on a wild goose chase searching for a "sky-hook"? Most Navy boots, Army recruits and apprentices in metalworking shops have been put through the tortures of the damned because they failed to deliver when sent to fetch the hook. Now, alas, that little bit of sport is about to be taken away from us, for progress has brought forth two types of sky-hook. In television there is a device for supporting heavy lighting fixtures which is officially called a sky-hook. Then, too, there is the Navy device which is said to have been the stimulus for all the talk about flying saucers. The huge plastics balloons which were sent aloft to radio back weather and atmospheric data were unofficially dubbed sky-hooks. Someone always feels compelled to spoil the fun.

T. C. Du Mond
Editor